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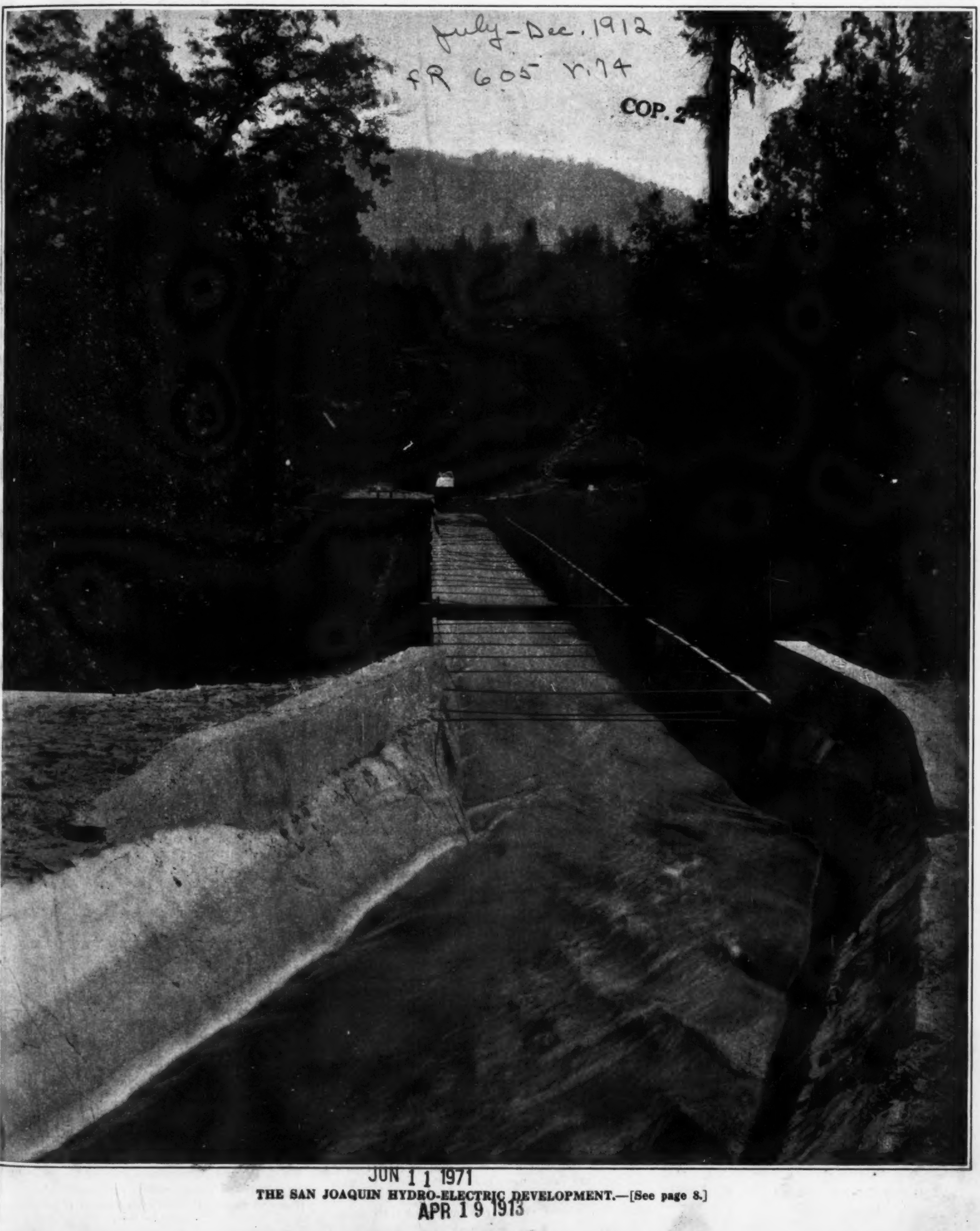


THE SAN JOAQUIN HYDRO-ELECTRIC DEVELOPMENT.—[See page 8.]

Tests of Vacuum Cleaner Apparatus*

Comparison of the Performance of Different Nozzles and Pumps

By M. S. Cooley †

THE tests described below were made by the author three years ago and were primarily to determine (1) the feasibility of using a carpet-cleaning test to determine the merits of a vacuum-cleaning system; (2) to fix the requirements to be incorporated in a specification where acceptance of the system was dependent on a satisfactory cleaning test; (3) to determine what requirements, rather than a cleaning test, would be necessary to obtain a first-class cleaning system.

In making carpet-cleaning tests, three types of carpet renovators were used which the author has referred to as types *A*, *B*, and *C*, in the order in which tests were made. Sections of these renovators are shown in Fig. 1.

Type *A* renovator has a cleaning slot 5/16 inch wide and 12 inches long in communication with a second slot which is open to the atmosphere through an opening under a dividing partition as shown in the figure. The partition stands 1/32 inch above the working face of the tool. Type *B* has a cleaning slot 1/8 inch wide and 12 inches long, with no opening for admission of air other than the cleaning slot. Type *C* has a cleaning slot 3/4 inch wide and 10 inches long, with no other opening for admission of air.

A number of preliminary tests were made with the object of obtaining some substance, with which carpet could be artificially soiled, which would be as difficult to remove as dirt ground in by usage. As a basis for comparison, a test was first made on a glue-sized Brussels carpet which had been in use for many years. This was divided into three parts, measuring approximately 7 square yards each and each containing, as was subsequently discovered, about 12 ounces of dirt. Each piece of carpet was cleaned during six periods of one minute each, using a different vacuum at the tool handle for each carpet. The carpets were weighed at the beginning of the test and after each one-minute period. At the conclusion of these tests each carpet was cleaned until no change in weight occurred after two minutes' cleaning. They were then considered 100 per cent clean, and this standard was used as a basis for computing the per cent of dirt removal given in Table I. The air consumption was computed from indicator cards taken from the vacuum pump during each test.

TABLE I. DUST REMOVAL TEST WITH TOOL A.

Vacuum in handle, in. Hg..	1	2½	4
Cubic feet air per minute..	30	43	50
Per cent dirt removed:			
In one minute..........	37	39	47
In three minutes........	59	66	71
In six minutes..........	67	82	90

A number of substances for artificially soiling the carpets were tried, including wheat flour, Portland cement and molders' sand. No material was found that was nearly so hard to remove as the dirt from a carpet soiled by usage. Finally dry sharp builders' sand, screened through a 50-mesh screen, was tried and found to be the most satisfactory. The results of tests made with this material are summarized in Table II.

TABLE II. SAND REMOVAL TEST: TOOL A.

Vacuum at handle, in. Hg....	1	2½	4
Cubic feet air per minute....	30	43	50
Per cent sand removed:			
In one minute............	45	61	50
In three minutes..........	73½	84	77
In five minutes............	..	94½	97

*Abstract of a paper read before the American Society of Heating and Ventilating Engineers and published in the *Engineering News*.

†Supervising Architect's Office, Treasury Department, Washington, D. C.

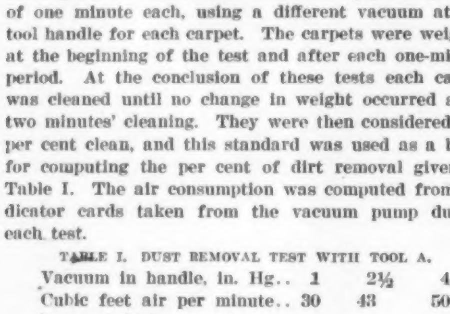


Fig. 2. Curves Showing Friction Loss in Vacuum-Cleaner Hose Lines.

When carpets were artificially soiled, the manner of making the tests was as follows: A carpet of known area was cleaned until no change in weight occurred in two minutes' cleaning and then weighed to the nearest quarter ounce. The screened sand was then weighed and sprinkled on the carpet and worked in with the feet until none of it could be seen on the surface of the carpet. It was found by experiment that

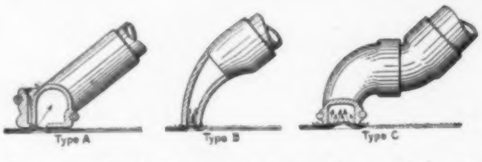


Fig. 1. Sectional Views of the Three Types of Cleaning Tools Tested.

no measureable loss of material occurred in working it in.

Similar tests with dry sharp sand were made on the same carpets as before, using type *B* renovator, with the result given in Table III.

TABLE III. SAND REMOVAL TEST: TOOL B.

Vacuum at handle, in. Hg.....	2	4½
Cubic feet air per minute.....	24½	39½
Per cent sand removed:		
In one minute..............	48	54
In three minutes...........	91	100
In four minutes............	100	...

Shortly afterward the author was afforded the opportunity to test a renovator of type *C*. The exhauster available, however, would not produce a vacuum of more than 6 inches of mercury, and this vacuum could not be readily controlled. These tests therefore were made with 3½-inch vacuum at the tool handle. The tests were run on a dirty carpet of 4 square yards area containing about 6 ounces of dust, and also on carpet filled with sand. The results are given in Table IV.

TABLE IV. TESTS WITH TOOL C.

	Dirt Test.	Sand Test.
Vacuum at handle.............	3½	3½
Cubic feet air per minute......	66	66
Per cent dirt or sand removed:		
In one minute...............	40	68
In two minutes..............	60	82
In three minutes............	90	100

Taking the results from all these tests with a vacuum at the tool handle of from 3½ to 4½ inches, the number of cubic feet of air required to remove 1 ounce of sand with the three types of renovators is as follows: Type *A*, 50 cubic feet; type *B*, 17 cubic feet; type *C*, 22 cubic feet. This is with carpet containing approximately 1 ounce of sand per square yard of carpet, which was the maximum that could be rubbed into the carpet used in the first test. Judging from tests on dirty carpet, this is approximately 80 per cent of the amount of dirt ordinarily to be found in a very dirty carpet.

An analysis of the tests shows that in order to clean the carpet effectively, we must have some degree of vacuum under the tool itself. Merely a current of air is not all that is required. For example, in the case of type *A* renovator, with 30 cubic feet of air passing and 1 inch of vacuum under the renovator, but 76 per cent of the sand was removed in four minutes. With type *B* renovator, with 24½ cubic feet of air passing and 2 inches of vacuum under the tool, 100 per cent of the sand was removed in the same time. On dirty carpets the result is even more marked. Apparently when working on a dirty carpet, it is the vacuum that loosens the dust from the carpet, the air acting as the conveying medium for removing the dirt loosened by the vacuum.

For a rapid, thorough and effective cleaning of carpets and other fabrics of equal weight and thickness, the author considers that a vacuum of at least 3½ inches at the tool handle is necessary. It is evident, however, from tests made of the effort required to move vacuum very much higher than 4 inches or 5 inches will cause the tool to stick and be hard to operate, and will be likely to cause undue wear on the carpet.

Comparing the efficiency of these renovators as dust removers, type *B* is more efficient than type *C* and both are vastly more efficient than type *A*. This can be accounted for by the construction of type *A* renovator, which receives the bulk of its air under the partition between the cleaning and the inrush slot, while both of the other types receive air under both sides of the cleaning slot, as indicated by the arrows in Fig. 1. In actual carpet cleaning, however, we have to pick up and move not only dust, but matches, bits of paper, and other litter which are obviously too large to pass the narrow slot of type *B* renovator. Therefore the ideal system would be one using type *C* renovator and arranged to maintain a constant vacuum of 3½ to 4 inches at the handle irrespective of the quantity of air passing.

HOSE AND PIPE-LINE FRICTION.

In a complete system, the elements between the renovator and the vacuum producer which affect the control of the vacuum at the renovator are the hose, pipe line and dust separators. Fig. 2 shows the results of actual tests of the friction loss in cleaning hose of 1, 1¼, 1½ and 2 inches diameter. In all the tests of type *A* and *B* renovators, 100 feet of 1-inch hose was used and a 15-inch vacuum was maintained at the hose cock. Under these conditions, the vacuum at the tool handle varied from 1 to 13 inches, owing to the variation in the quantity of air passing into the renovators when operated on various surfaces. The variation in vacuum was considerably less with type *A* renovator than with type *B*, owing to the effect of the inrush slot which acts as a vacuum breaker when the renovator is operated on smooth surfaces or dense fabrics. This, however, is obtained only at a sacrifice in cleaning efficiency, as the leakage or by-pass effect of the inrush slot is always present.

Much better results, moreover, can be obtained by using type *B* or *C* renovators connected with 1½-inch hose. In this way the total variation in vacuum, when operating on various kinds of surface, will not exceed 1 inch for type *B* renovator, nor 1½ inch for type *C*, without recourse to any type of vacuum breaker in the renovator or tool handle.

Pipe lines add their friction effect to that of the hose line, but in a far less marked degree, as they are seldom made less than 2 inches in diameter. With a system so designed that the maximum length of hose necessary will not exceed 75 feet, and with the 1½-inch diameter hose and ample sized pipe line, the maximum loss in vacuum between the tool handle and the vacuum producer will not exceed 3 inches. In designing pipe lines, care must be exercised that the velocity in these lines never fall below 2,500 feet per minute, otherwise dust will be deposited in the pipe line.

VACUUM PUMPS.

Fig. 3 shows curves of power consumption of six different types of vacuum producers, based on tests made by the author. Curve *A* is from a reciprocating-piston air compressor used as a vacuum pump. Curve *B* is from a reciprocating-piston vacuum pump especially designed for vacuum cleaning and shows a higher economy than *A*. Curve *C* is from a single-impeller sliding-vane rotary vacuum pump and shows equal economy to *B* up to 12 inches of vacuum, above which its efficiency falls off. Curve *D* is from a double-impeller rotary vacuum pump, water sealed, which shows much better economy than *B* below 14½ inches of vacuum. Curve *E* is from an early type of multi-stage centrifugal fan and shows an efficiency about equal to *B* and *C*. Curve *F* is from a recent type of multi-stage centrifugal fan and shows an efficiency better than any other except *D*.

At 6 inches of vacuum these producers can be rated

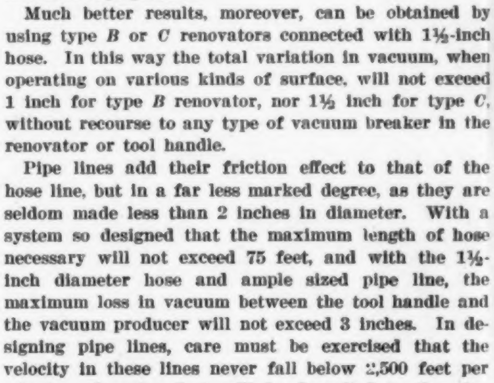


Fig. 3. Power Consumption Curves of Six Different Types of Vacuum-Producing Apparatus.

[Power consumption shown in watts per cu. ft. of free air exhausted per min.]

n the following order relative to efficiency: First, *D*; second, *F*; third, *B*; fourth, *E*; fifth, *C*; sixth *A*. Type *F* maintains a constant vacuum due to inherent properties of its construction, and where first cost is of vital consideration its use might be preferable to that of *D*. Both *D* and *F* are subject to considerable noise and vibration unless the peripheral velocities of fan and impellers are limited. The author recommends a maximum velocity of impeller tips of 1,100 feet per minute in *B* and not over 1,500 feet per minute in *F*.

SUMMARY.

The author considers that to obtain the best results in a cleaning system the width of cleaning slot should be required to be not less than ½ inch, the length of the renovator not less than 12 inches, the diameter of the hose 1½inches; that the pipe line should not be less than 2½ inches in diameter except where lifts occur, where 2 inches should be used; that the vacuum control be set to maintain 6 or 7 inches of vacuum at the machine.

The following test is suggested to give the best results: Fit a 1½-inch diameter pipe 3 feet long into the end of the hose with a diaphragm at the outer end and a vacuum gage or mercury column near the hose. Require a vacuum at mercury column of 3 inches with 65 cubic feet of air passing into the tube and as many hose lines and tubes in operation as the number of sweepers desired in the system. This test requires approximately a ⅝-inch diameter opening in the diaphragm.

An Example of Motion Study*

And Some General Reflections on the Subject

By Charles S. Miller

Motion Study is a valuable and useful instrument to use in performing the operation of cutting costs. It is also a dangerous instrument, this on account of two principal reasons:

1. It takes time to make motion studies, and a great deal of money can be very quickly spent in making observations which may develop later as having little or no practical value.

2. Unless the workmen are handled right, they are apt to get the impression that the studies are being made with the sole purpose in view of cutting rates.

DIFFERENCE BETWEEN MOTION AND TIME STUDIES.

In the mind of the uninformed there is apt to be some confusion between Motion and Time Study. We might say the former is qualitative and the latter quantitative. Motion study analyses determine the proper elementary motions necessary to accomplish a certain act. They eliminate all unnecessary motions and determine the arrangement of the work to enable the operator to execute the sequence of motions with the least expenditure of effort and time. It is a motion study that effects savings.

Time study is measure; it determines standards by which we can measure the relative efficiency of the old and new methods. It serves as the basis in setting prices on piece work or the standard time on bonus work. Time study is complementary to motion study. It is necessary so that we may establish standards which must be lived up to by the operator, and these standards can only be reached by operators working under this new method.

NAILING DOWN NEW METHODS.

To the average workman it seems too much trouble to make the effort to break away from the old method of doing his job and working his mind long enough to create brain channels that will telegraph the new motions to his hands. Written instructions, wage incentive, personal direction, and, for a time at least, constant supervision, are all necessary. In the case of much foreign labor the work must be done without the written instructions to the workman. After a time increased wage return, less fatigue and the habit formed of doing the work in the correct way, insure the performance of the operation in the standardized manner. The matter of training workmen in habits of industry, in the doing of their work in the proper manner, has a humanitarian as well as a commercial aspect.

One feature of time study is worth mentioning, though it is opposed to the fundamental principle of mutual confidence between employer and workman; it is practically impossible for an operator to fool an experienced motion and time study man by "soldiering" on a job under observation. Five or ten timings of the elementary motions in an operation, establishing a standard time for each motion, not an average, and summing the unit standard times, will invariably give a fair total time for the complete operation.

In addition to establishing a standard method of accomplishing a job, motion study brings the individual workman under close observation, and this enables the employer to fit the workman to the job. It makes possible the consideration of the personal equation of the operator in selecting him for a certain operation.

I will now give examples of motion study taken from actual practice. Comparatively simple operations have been chosen, both on account of the greater clarity in description and because it is in the simpler operations that often lies the opportunity of greater economy in movement rather than in those of more complexity.

AN APPLICATION OF MOTION STUDY.

Making final sizing cut on taps and gaging diameter of top and bottom of threads. The cut is made on a vertical drill press with a die set in the bed plate and the tap is gripped in the chuck and forced down through the die, falling into a pan under the press. The work is gaged in two "pass and stop" gages placed on the left of the bed of the press. By the old method the unfinished work was in a box on the left of the machine; the finished work in a box on the right. The sequence of motions was as follows:

1. Reach 2 feet to left of box of unfinished work.
2. Pick up tap with left hand.
3. Bring tap to chuck.
4. Slip squared end of shank into chuck with left hand.
5. Reach over with right hand and lower head of press, passing tap through die until it falls into pan under press.
6. Reach under press with right hand and pick up tap.
7. Lift tap from pan to gages on left of press.
8. Pass through gages.
9. Transfer tap from left hand to right hand.
10. Put in box of finished work.

Now for the new method. The box of unfinished work was placed closer to the operator and the box of finished work placed beside it on the left side of the press. A small sheet iron chute was placed under the press so the tap would slide to the front when it fell from the die. The right hand of the operator grips the lever of the head continually. A better arrangement would have been to put an attachment on the press, to actuate the head by foot, but this change was not made in this instance.

Starting with the operator gripping this lever with his right hand and his left in the box of finished work where he has just placed his last finished piece, the new sequence of motions is as follows:

1. Move the left hand about 6 inches toward the chuck to the box of unfinished work.
2. Pick up tap with left hand.
3. Bring tap to chuck.
4. Slip squared end of shank into chuck with left hand.
5. Lower head with right hand, passing tap through die. While doing this with the right hand, execute the following motions with the left:
    a. Pick up previous tap from pan between knees.
    b. Lift tap to gages.
    c. Pass through gages.
    d. Reach to box of finished work and lay down tap.

In this operation a saving of 50 per cent in the time was effected by the new method. A $1.50 a day man was sizing about 700 pieces per day, costing the company about 21 cents per hundred. By setting a piece work rate of 14 cents per hundred, the operator was able to earn approximately $2.00 per day by the new method and the company saved one-third of the direct labor cost of the operation.

PRINCIPLE APPLIED TO GRINDING OF REAMERS.

The grinding was being accomplished in two distinct operations, the grinder being set first for the roughing grind and a lot of several hundred put through, then changed for the finishing grind and the lot put through the second time. The work was placed in a dog, inserted in the carriage chuck, clamped, and the carriage traveled forward and back automatically. During this time the operator took the dog off the last accomplished piece of work, put this piece in a box, picked up another piece of work, put on the dog, then "sat" until the grinding was finished.

By the old method the sequence of motions and the unit time of each motion was as follows:

1. Pick up reamer and attach dog............0.09 min.
2. Stop machine, take out and put in work and start machine..........................0.13 min.
3. Grinding (automatic)..........................0.30 min.
4. Remove work from dog and put in box......0.07 min.

Operations 1 and 4 are accomplished during (3) so that the elapsed time for one cycle of operations was 0.43 minutes, during which the operator was idle 0.14 minutes or 1/3 of the total time. Thirty-three and one third per cent rest in this instance was very considerably more than a man required to work without undue fatigue. The problem was how to utilize this idle time—0.14 minutes in every 0.43 minutes.

As two grinds were necessary to bring the reamers to final size, the sequence given above was repeated, the machine being readjusted after the first lot was finished. It will be noted then that the total time for the two grinds on each piece, exclusive of any time for machine set up or adjustment, personal needs of the operator, etc., was 2×0.43 equal to 0.86 minutes. As this example is for comparisons of the actual machine time between the old and new methods, the factors outside of this are not discussed here, though careful study would have to be made of same before setting a standard task.

By the new method the operator will be provided with two machines, indicated hereafter as machine *R* for roughing grind and machine *F* for finishing grind. The machines should be set face to face about 4 feet apart. Starting at machine *R*, the sequence of motions and the unit times of same would be as follows:

At Machine R.

1. Pick up reamer and put in dog..............0.09 min.
2. Stop machine, take and put in work and start machine..............................0.13 min.
3. Grinding (automatic)..........................0.30 min.
4. Turn and step to Machine *F*................0.02 min.

At Machine F.

5. Stop machine, take out and put in work and start machine...........................0.13 min.
6. Grinding (automatic)..........................0.30 min.
7. Remove dog and put finished reamer in box..0.07 min.
8. Step to Machine *R*.........................0.02 min.

Remembering that operations 3 and 6 are automatic, we find the sum of the time of the other operations to be 0.46 minutes for completing both grindings.

The comparison would consequently be as follows:

Old method time per 100 pieces, two grindings....83 min.
New method time per 100 pieces, two grindings..46 min.

Saving....................................37 min.
Per cent time saved..............44½

In this particular case two additional factors must be considered: 1. Will the volume of work be sufficient to bring justifiable returns on the investment in one additional machine. 2. What percentage of time will the machines lie idle between the time the grinding is automatically completed and the workman gets the machine started again. In this case we find that it takes the workman 0.33 minutes to complete his cycle of operations from the time the machine is started until he returns to unload and load the machine. As the automatic operation requires only 0.30 minutes, there will be 0.03 minutes lost on each machine on each operation, or the machine efficiency will be 91 per cent as compared with the old methods.

Assuming that there is sufficient work to keep both machines busy, that each machine costs $250 and that 20 per cent of this cost is the yearly charge for repairs and depreciation, we find the yearly cost of the additional machine to be $50. A 20-cent an hour man was doing this work. His income, working full time, would be $572 per year. Deducting 20 per cent from this as the amount paid for unproductive time, that is, time for setting and adjusting machines, personal needs, etc., and taking 44½ per cent of the result, we find a saving in labor by the new method of $210 per year. Deducting the $50 machine cost, the company would save on this one simple operation $160 per year, the interest on $2,667 at 6 per cent.

* From a paper read before the American Supply and Machinery Manufacturers' Association, Norfolk, Va., May 13th, and published in *The Iron Age*.

Post-Office Tests.—Interesting experiments have recently been made by the *Matin* (a Paris newspaper), in order to test the efficiency of the post-office service in the various countries. Arrangements were made with the *Matin's* representatives in seventeen of the largest cities in Europe, to enter the post-office at the same time (Saturday, May 25th, 5 P. M.), ask for a telephone call to a town at least 100 kilometers (62½ miles) distant, despatch a telegram and purchase a money order. The following is the result as reported from the principal cities: London was fastest in sending telegrams, the time required was but 30 seconds; in Paris it took 1 minute; in Rome, 1 minute, 41 seconds; in Berlin, 2 minutes, 40 seconds, and in Brussels, 3 minutes. In telephoning Brussels excels, the time taken was 55 seconds; at the other cities the times were: London, 6 minutes, 2 seconds; Paris, 7 minutes; Berlin, 13 minutes, and Rome, 1 hour, 16 minutes. The time required in purchasing postal orders was as follows: London, 1 minute, 36 seconds; Rome, 2 minutes, 34 seconds; Paris, 4 minutes; Berlin, 11 minutes, and Brussels, 14 minutes. The postal service in London therefore seems to be the fastest and most efficient.

The Tatin-Paulhan Aero-Torpedo

A Successful Rear-propeller Machine

By John Jay Ide

About two years ago there was exhibited in the Louvre stores in Paris a monoplane having its propeller in the rear. This machine never gave satisfaction to its crea ors, M. Feure and Armand Deperdussin, the latter of whom soon turned to the generally accepted type of monoplane with what results we have seen in the recent startling performances of Védrines. In England, the Petre Brothers exhibited a monoplane incorporating the propeller at the extreme rear in the Olympia aero show, London, in 1910. The tests which followed had to be brought to a conclusion in view of the difficulties in the way of the successful application of this principle.

In view, therefore, of the apparent impossibility of producing a satisfactory machine of this type, the appearance in the autumn of 1911 of a new monoplane with rear-driven propeller caused expressions of doubt as to its ultimate success. This time, however, the critics were disappointed; the new aero-torpedo, built by Louis Paulhan to the designs of Victor Tatin, has proved to be the most efficient monoplane in existence.

An examination of the machine reveals the most painstaking thought devoted to the development of each individual part. Much of its speed is due to its general shape, but the efficiency of the whole is largely increased by the extreme refinement of all the details. First and foremost, the aim in the design of the aero-torpedo has been to achieve the maximum efficiency by suppressing, to as great an extent as possible, the parts of the machine which present resistance to forward advance and so absorb power without turning it to any practical advantage.

The fuselage, covered throughout its whole length by fabric, is as near true stream-line form as it can conveniently be made. The covering is supported on light wooden hoops which surround the body proper, which is a lattice girder of the customary type, rectangular in section.

The pilot, seated in the bow, commands an uninterrupted view of the country ahead of him, although he is placed so low that only his head emerges. Furthermore, he is not in a position to be sprayed with oil from the motor. Some critics may object to the position of the pilot's seat on the score of danger in case of overturning on making a heavy landing. The long tapering nose, however, in relation with the low landing carriage, would make such an occurrence improbable.

The controls consist of a hand lever and a foot tiller yoke. The lever is moved forward and backward to operate the elevator and sideways to warp the wings. The foot yoke controls the rudder as in the Blériot.

Immediately behind the pilot in the interior of the fuselage is mounted the motor, a fifty horse-power Gnôme. In its vicinity a louvered metal shield is substituted for the fabric covering. This shield is made detachable so as not to interfere with the accessibility of the engine. The position of the motor has been another cause for criticism by those who look askance at any display of originality and who are only too ready to standardize aeroplane design which, as a matter of fact, is at yet only in a purely experimental state. At first sight the cooling facilities of the engine may seem insufficient, but the constructors have held long tests both on the ground and in the air and there have been no symptoms of overheating.

Many authorities claim that the day of the rotary motor is almost over on account of the excessive head resistance which it presents. Since the motor as placed in the Tatin-Paulhan offers no head resistance whatever, it would seem that the rotary type may yet survive, as it is greatly superior to the stationary type in regard to weight and general efficiency.

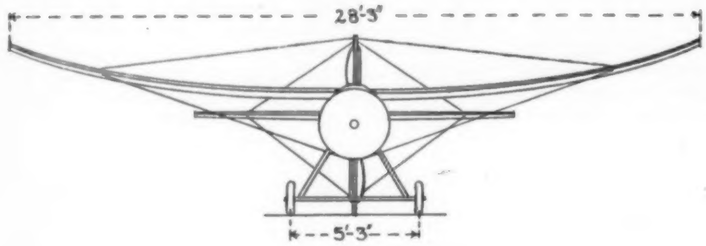
The connection between the motor and propeller is made by a shaft supported at intervals along its length by six ball bearings, each of them strung into position by steel wires. In the first model turned out, the propeller shaft was furnished with a couple of universal joints, but the ability of the fuselage to resist torsional and flexural strains has been shown to be so great by tests at the Arts and Metiers Institution in Paris that the joints have been abandoned. This necessitates such extreme care in mounting the shaft and bearings that it is questionable whether the universal joints should have been abandoned.

The wings in plan resemble an ellipse with its tips cut away by lines parallel to its minor axis. In front elevation they have an appearance of an ellipse cut by a line parallel to and below the major axis. This special wing shape is held by the designer to give considerable natural lateral stability, and so convinced was he of its effectiveness that he provided absolutely no warping in the first model. In the machines turned out at present, however, the wings are capable of being warped slightly. In cross-section the wings exhibit very little curvature and their angle of incidence is likewise extremely small. They are supported by flat steel bands proceeding from a mast on the body. There is no pylon below the fuselage, the steel bands below the wings being attached to the body proper. The rear set of bands operates the wing flexing.

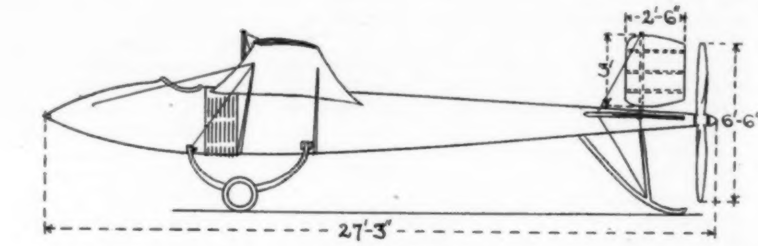
At the rear end of the body is arranged the tail, almost identical in plan form with the wings. An absolutely flat surface plays the part of stabilizer and behind it is hinged the elevator, composed of a pair of simple flaps. Mounted vertically above this surface is the directional rudder which is balanced and approximately rectangular in shape.

At the extreme rear is the Régy Frères propeller of eight feet pitch. As it revolves in the region of air disturbance which follows the passage of the machine it is enabled to work with great efficiency. The belled-out aluminium cone which effects the final "run-off" of the propeller boss is indicative of the care which has been devoted even to minor details to avoid head resistance losses. The propeller is protected from contact with the ground bya high skid. As it is impossible to lower the tail any appreciable amount, some difficulty must be encountered in getting the machine to leave the ground quickly on commencing a flight. Also, since it is so tremendously fast, it must require a very long length of ground to come to rest after landing. To overcome this objection some sort of brake should be fitted, as large landing spaces cannot be safely relied upon.

The landing carriage is extremely strong and simple. The axle uniting the wheels which, by the way, are covered with spun steel disks, is attached to two arcs of hickory. These arcs are hinged to the fuselage at their forward extremities and at their rear ends they are united by a strong piece of wood which in turn is strapped by means of cotton covered rubber cord to a reinforced cross-member of the lattice girder body. No attempt has been made in the landing carriage to provide for sidewise displacement on landing.



Rear Elevation.

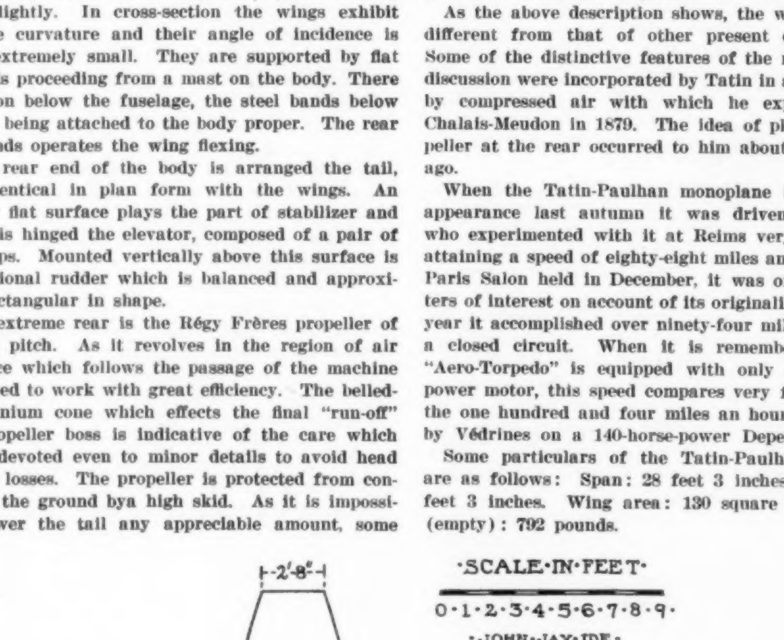


Side Elevation.

As the above description shows, the whole design is different from that of other present day machines. Some of the distinctive features of the machine under discussion were incorporated by Tatin in a model driven by compressed air with which he experimented at Chalais-Meudon in 1879. The idea of placing the propeller at the rear occurred to him about twenty years ago.

When the Tatin-Paulhan monoplane first made its appearance last autumn it was driven by Gaudart, who experimented with it at Reims very successfully, attaining a speed of eighty-eight miles an hour. At the Paris Salon held in December, it was one of the centers of interest on account of its originality. Early this year it accomplished over ninety-four miles an hour on a closed circuit. When it is remembered that the "Aero-Torpedo" is equipped with only a fifty horse-power motor, this speed compares very favorably with the one hundred and four miles an hour accomplished by Védrines on a 140-horse-power Deperdussin.

Some particulars of the Tatin-Paulhan monoplane are as follows: Span: 28 feet 3 inches. Length: 27 feet 3 inches. Wing area: 130 square feet. Weight (empty): 792 pounds.



Plan.

Temperature and the Properties of Matter

From Absolute Zero to Six Thousand Degrees Centigrade

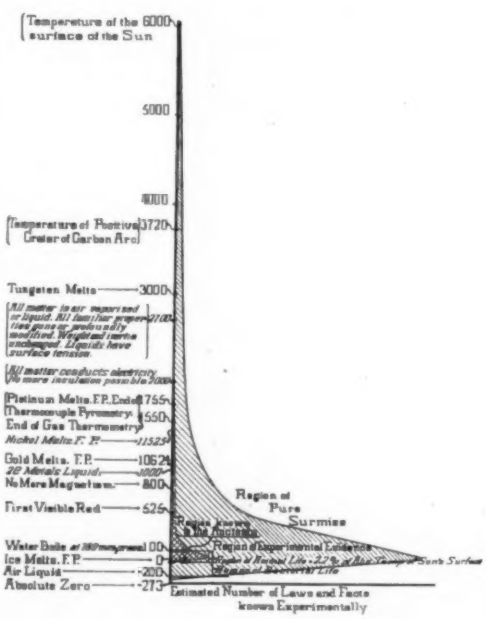
By Prof. E. F. Northrup

Our understanding of what we term heat is a deduction from phenomena of which we have a direct sense perception. Heat is not directly perceived by any of the senses, but temperature is. In addition to the five senses ordinarily assigned, there is undoubtedly a true temperature-sense. This temperature-sense is more delicate than is ordinarily supposed. If you plunge you finger first into one glass of water, and then into another, you can feel that they are unlike in temperature if they differ by so little as ¼ deg. Cent. Our temperature-sense for which we probably have an independent set of nerve fibers, only enables us, however, to perceive accurately small *differences* in temperature; the absolute value of any temperature can be judged only very roughly and through a range of but a few degrees. In an analogous way the ear can perceive with great exactness small differences of pitch between two notes, but a keynote must be sounded upon an instrument to enable, in most cases, even trained singers "to get the pitch."

Since our temperature-sense is insufficient to furnish an accurate scale of temperature, resort must be had for this purpose to some physical modification in one of the properties of matter which occurs in a regular way with temperature change. The physical means which has been most successfully adopted for establishing a scale of temperature is the change which occurs, when the temperature changes, in the pressure of a gas inclosed in a vessel of constant volume. It is approximately true that the pressure of nitrogen gas, when its volume is maintained constant, is proportional to its temperature and that the pressure of this gas diminishes 1/273 of the pressure which it has at the temperature of melting ice, for every degree centigrade that its temperature is lowered. Hence, if the law continued to hold and the temperature were lowered 273 deg. Cent. below the temperature of melting ice the gas would have no pressure. The law does not so hold with any actual gas. But Lord Kelvin has shown from thermodynamic considerations that the performance of an ideal gas, in which the law does hold, may be used to assign the lower limit of temperature and to establish an absolute scale of temperature. If a gas has no pressure this means that it is incapable of doing any work, such as raising a piston in a cylinder—or in other words the gas has been robbed of all its energy. When matter has no more energy we speak of it as being absolutely cold and, in a sense, it is dead. The absolute zero of temperature, upon the arbitrary centigrade scale, is, then, 273 deg. Cent. below the temperature at which ice melts and 373 deg. Cent. below the temperature at which water boils under the standard pressure of 760 millimeters of mercury.

The establishment and the increasing of the range of the so-called scale of gas-thermometry has occupied the labors of many physicists of the first rank. The most notable advances in gas-thermometry have been made within the last few years at the Geophysical Laboratory at Washington, D. C., of which Dr. Arthur L. Day is director. In a publication[1] from this laboratory dated February, 1910, the statement is made that the nitrogen-gas-thermometry scale has been extended by direct observation to the upper limit of 1550 deg. Cent. with a plus or minus error not exceeding 2 deg. Cent. Here it must be noted that all extensions of the thermodynamic absolute scale of temperature above this temperature are in the nature of extrapolations. An extrapolation based upon the thermal e.m.f. of a platinum-rhodium thermo-couple has been made up to the melting point of platinum. Other and higher extrapolations are all based upon the assumed truth of two prominent laws of radiation-pyrometry. Extrapolating to the melting point of platinum by the above two methods the agreement is such as to justify an assignment of 1775 deg. Cent. with a plus or minus error not exceeding 5 deg. Cent. as the temperature upon the absolute thermodynamic scale at which this metal melts. All that we know of temperatures beyond this is learned solely from the radiant properties of matter.

To fix the scale of temperature up to the melting point of platinum so that this scale may be readily reproduced in any part of the world, physicists have sought for properties of matter which change in a distinct and reproducible way at various points along the temperature scale. Thus for the range of temperature between the freezing and vaporization of mercury, namely, 39.5 degrees and 357.2 deg. Cent. the volume-expansion of this metal in glass or quartz thermometers has proved most convenient. For lower and higher temperatures other properties of matter must be used as reference points. Of all the properties of matter which change with temperature the four which have seemed best to meet the requirements are: the expansion of liquids or solids, the change in the electrical resistance of metals, the thermal e.m.f.s. in electric circuits of unlike metals, which have junction points at different temperatures, and the change of state or melting of pure metals and salts which occur sharply at definite temperatures. The most important work of recent years in the fixing of the upper portion of the scale of temperature to the melting point of platinum, has come from the Geophysical Laboratory. The chief object has been to determine very precisely at what temperature, according to the nitrogen-gas-thermometer certain metals and salts, easily obtainable in a state of purity, melt, what e.m.f.s. are produced in certain thermo-couple thermometers of standard composition and how the resistivity of pure platinum varies with the temperature. This work has been largely supplemented, especially in reference to platinum-resistance-thermometry, by the work of the Bureau of Standards at Washington. The fixed temperature points at which



standard substances melt and which form a temperature scale by which temperature measuring devices may be calibrated are given in the following list:

The American Journal of Science, Vol. XXX, July, 1910, page 6.

Ice, m.p.	0.0°
Water, b.p.	100.0° + 0.037 (p — 760)
Naphthalene, b.p.	217.7° + 0.057 (p — 760)
Benzophenon, b.p.	305.4° + 0.063 (p — 760)
Cadmium, m.p.	320.2°
Zinc, m.p.	418.2°
Antimony, m.p. (in CO)	629.2°
Silver, m.p. (in CO)	960.0°
Gold, m.p.	1062.4°
Copper, m.p. (in CO)	1082.6°
Diopside, m.p.	1391.2°
Nickel, m.p. (in N_2)	1452.3°
Cobalt, m.p. (in N_2)	1489.8°
Palladium, m.p.	1549.2° within ± 2° C.
Platinum, m.p.	1755.0° within ± 5° C.

With these fixed points assigned any thermo-couple of platinum and platinum-rhodium may have its curve of temperature against thermal e.m.f. determined in any part of the world, when it in turn becomes a secondary standard for the measurement of temperature to the melting point of platinum within an accuracy at the upper limit of approximately 5 degrees. One has little conception of the long and painstaking investigation which has been required to obtain the above list of fixed temperature points. Dr. A. L. Day remarks (Trans. of the Faraday Society, p. 145, November, 1911): "The way is now open for a direct and accurate calibration of radiation pyrometers throughout the region between 900 deg. Cent. and 1550 deg. Cent., which should afford a much more certain basis for extrapolation to those extreme temperatures which no laboratory apparatus can withstand."

The methods of optical pyrometry can only be referred to here, as the subject is an extensive one. Suffice it to say, that they depend upon two laws of radiation, one known as the Stefan and Boltzman law, which states that the total energy which is radiated from the bottom of a deep hole in a body made of any substance is proportional to the fourth power of the absolute temperature. In mathematical language $E = K\ (T^4 - T_0^4)$ where T is the absolute temperature at the bottom of the hole, or so called "black body," and T_0 the absolute temperature of the body on which the radiation falls. The other is known as Wien's law which states that as the temperature of the radiating source is changed the wave length having maximum energy in the spectrum will be changed in such a way that the product of this wave length and the corresponding absolute temperature of the source, is constant. Or otherwise expressed when the temperature increases the wave length of maximum energy shifts toward shorter wave lengths.

The first law is made the basis of pyrometers of the Féry type in which the total radiation from the black body source is focused upon a thermo-junction. The temperature being measured is then interpreted in terms of the deflection of a galvanometer, which if desired, may be automatically recorded. The second law is made the basis of a variety of optical pyrometers, known under such names as the Wanner, the Le Chatelier, the Morse, etc. As in all these the temperature is interpreted by means of the eye automatic recording of the temperature has not been effected. All radiation pyrometers must be calibrated empirically, the calibration extending from about 900 deg. Cent., to the melting point of platinum. Above this temperature the curve which is assumed to obey the radiation law is a curve of extrapolation, upon data given by the gas-thermometer.

The very high temperatures which are assigned to the sun and stars, to the interior of electric furnaces, or to the positive crater of the electric arc, must all be estimated—one can scarcely say measured—by radiation pyrometers which operate over the extrapolated portion of their calibration curve.

Physicists feel confident as to the lower range of the temperature scale, but its upper limits can only be conjectured. No one pretends to know what inconceivable temperatures may exist in the interior of blazing suns. The surface temperature of some of the stars has been estimated, upon the basis of optical pyrometry, to be 10,000 degrees or more. We will try to help out our imagination of the portion of the temperature scale which has been observed and our corresponding knowledge of the properties of matter at various points along this scale, by means of a chart.

First, we note, in viewing this chart, that if we take the estimated temperature of the surface of the sun as 6000 deg. Cent. at which temperature we possess but a vague knowledge of the properties of matter, and if we call the range in which human life exists as 140 deg. Cent., then the region of temperature in which we live is only about 2.2 per cent of the absolute temperature which we study and talk about. In other words, we can only have a direct sense perception of between 2 and 3 per cent of the total range of temperature which we study with instruments. Starting in imagination at the absolute zero or—273 deg. Cent. we conceive all matter to be without motion, without energy. It is dead. This final condition has never been observed, but where hydrogen is frozen and helium-gas liquid the absolute zero has been reached within 3 or 4 degrees and the condition, and a very few of the properties of several kinds of matter, have been observed.

Here the suggestion is offered, that as metallic conductors have an enormous conductivity, and as the transport of electricity in metals is presumably carried on by mobile negative electrons which obey the laws deduced from the kinetic theory of gases, we have the result that where matter is without energy and dead electricity is active and in motion. It may well be, therefore, that far below the absolute zero for matter there is another zero for electricity where the active electrons themselves become quiescent. While it is pure speculation it is interesting to inquire if there may not exist a cold for electricity in comparison with which the absolute zero for matter is a white heat.

At — 200 deg. Cent., or 73 degrees absolute, air is liquid. If any astronomical cause, or the lapse of time should permanently lower the lowest temperatures

[1] See also the article by Day, in *Metallurgical and Chemical Engineering*, Vol. III, p. 257.

which now prevail upon our earth by only some 100 deg. Cent. the watery fluids of the earth would become plains of hard crystalline rock which much of the now enveloping atmosphere would cover like a soft white snow, for the cold would precipitate it upon a frozen and dead world. We now easily produce this temperature in making liquid air and it is found that many kinds, at least, of the bacteria which are at once man's friends and deadliest foes, still survive. Between —200 deg. Cent. and —40 deg. Cent., practically no other life is possible unless it be some low vegetable forms and plant spores. At about —40 deg. Cent. the higher order of animal life takes its permanent abode upon earth. Antartic explorers find the emperor penguin living comfortably in large flocks where, as Amundsen recorded, the temperature never rose higher than —5 deg. Cent. and where it often remains below —40 deg. Cent.

At 37 deg. Cent., the blood heat of warm blooded animals, life upon this earth teems. But ascend only 63 deg. Cent., or a little over 1 per cent of the temperature of the sun's surface, and water boils and all life, including the hardy bacilli, is destroyed. Since the earth as a whole has probably never been colder than it is at present, it is worthy of remark that in the several millions of years that life has been upon its surface the temperature cannot have changed so much as 2 per cent of the temperature of the surface of the sun. It would take but a trifling irregularity in the customary course of the solar system—as the falling of a considerable mass into the sun—to raise the temperature of our earth some 60 deg. Cent. In this event all protoplasm—the life stuff—would be cooked and two of the three kingdoms on earth, the animal, vegetable, and mineral, would cease to exist.

In the range 100 deg. Cent. to about 525 deg. Cent. matter can only be inorganic, and it is not self-luminous If it is to be seen, it must be illuminated by light from an independent source cast upon it. But Draper has shown that at about a temperature of 525 deg. Cent. matter of all kinds begin to furnish a faint red glow. The activity of the motion of its particles becomes so great that the ether disturbances produced are able to affect our eyes and as the temperature steadily rises this first faint red glow becomes stronger; orange, yellow, green, blue, indigo and violet rays are successively added with increasing elevation of temperature, until finally the dazzling blue is reached which is found at the temperature of the positive crater of the arc lamp, a temperature which must be attributed some threefold to the surface of the blue stars.

It may be said that below —40 deg. Cent. matter reveals only faint indications of the life within it which at the absolute zero passes into complete death; that from —40 deg. Cent. to 100 deg. Cent. it exhibits an abundant visible life seen in the activity of the protoplasm which it produces, that from 100 degs. Cent. to 525 deg. Cent. the life in matter, though not visible to the eye, is to be conjectured from its mass movements and phenomena of contraction and expansion and that above this temperature the life in matter reveals itself with ever increasing visibility until eyes are blinded with the radiant energy which its vibrating particles give rise to.

At about 1000 deg. Cent. we find at least twenty-seven out of some fifty known metals are molten and flow like mercury. Here chemical activities are immensely increased, which changes the identity of almost all familiar compounds. Our common experience of the chemical properties of bodies and elements avails us little in predicting the chemical reactions which will take place. It thus happens that physicists unfamiliar with high temperature work can make little use of their experience acquired at ordinary temperatures in predicting the nature of the phenomena which, under given conditions, may be expected at this elevated temperature. It is for this reason that even at this moderately high temperature investigation has become a specialty.

At 1550 deg. Cent. gas-thermometry ends. When the Carnegie Institution at Washington started its investigations the gas-thermometer scale had only been extended, with any pretense at precision, to 1100 deg. Cent. The recent gain of 450 degrees is largely due to the splendid work of Dr. Arthur L. Day, the director of the Gophysical Laboratory. At 1775 deg. Cent. platinum, the metal par excellence for measuring temperature, has itself become a liquid. As thermo-couples for high temperature work have always been made of this metal in combination with platinum alloyed with rhodium or iridium, thermo-couples thermometry must end at this temperature unless some heretofore untried metals of still higher melting point be used for the purpose. It is not impossible that molybdenum-tungsten thermo-couples properly protected in an atmosphere of hydrogen might be used under certain circumstances to temperatures up to their exalted melting points.

At 2000 deg. Cent. almost all substances known to us will be plastic, gaseous or molten. The physical properties of matter at this temperature are but vaguely comprehended. Certainly most familiar properties have gone. All magnetism of matter was left far behind at about 800 deg. Cent. At this temperature all matter is conducting and there are no more insulators of electricity. If at 2000 deg. Cent. we are to have electric currents they can only be produced as eddy currents—for no insulators can be found to lead the electric current into directed paths. Ascend another 700 degrees or 800 degrees and all matter, in ordinary atmosphere, will have entered into new chemical combinations, have become liquid or vaporized. It will possess but four or five of the many familiar properties of matter we study and about which we consider we know so much. Hardness, porosity, tensile strength, ductility, elasticity, stability of form, magnetism, color, etc., are all gone. Density, expansibility, thermal and electrical conductivity are profoundly modified. Even the air surrounding such matter has become a conductor due to the thermions which the glowing matter freely emits in abundance.

Two fundamental properties remain, however, constant and unmodified. These two properties are inertia and weight. The kinetic energy of a unit mass of matter moving with a given velocity is just the same at a temperature of 2000 degrees as it is at the temperature of the room, while the earth will attract this matter with the same force whatever its temperature. The surface tension of molten metals persists up to their vaporization point. A portion of molten platinum will form into a liquid globule and roll like quicksilver, and even tungsten which resists before melting almost the highest temperatures we can produce on earth, will gather, when melted, into a bead. This persistence of surface tension strongly suggests that the ultimate particles of matter are attracted toward one another by the same force—gravitation—which draws all bodies—whatever be their temperature—with the one universal law discovered by Newton.

In an atmosphere of hydrogen three at least, and perhaps one or two more metals, recently studied in respect to their melting points, seem to resist fusion up to an elevation of temperature of about 3000 deg. Cent. Mr. Forsythe of the University of Wisconsin finds the melting points of tungsten and tantalum to be in the neighborhood of this temperature and when they melt they form a well defined bead in contrast with carbon which has no true melting point, but at about 3700 deg. Cent. evaporates or sublimes.

Beyond the temperature range of the vaporization of carbon—and we have only reached a little over half way to the estimated temperature of the sun's surface—nothing whatever is known about the properties of matter beyond those which we can infer by studying the radiant energy which it gives off and from observing the manner in which it is acted upon by gravitation.

Our most extensive knowledge respecting the properties of matter is at the habitual temperature in which we live and try most of our laboratory experiments. The past history of physics is, in the main, a recital of the properties, the phenomena, and the laws of matter in the accidental and transitory range of temperature from melting ice to boiling water. If matter at the center of the sun is, as Arrhenius speculates, at the inconceivable temperature of 6,000,000 degrees—being 6000 degrees at its surface and increasing from the surface to the center about 9 deg. Cent. per kilometer—then the petty range of temperature in which we study matter is but about 1/60,000 of the total range of temperature in which the matter of our solar system exists.

If in our chart we let the height of the straight line represent temperature elevation and if we represent, by distances measured to the right of this line, the number of facts and laws of matter about which we have gathered true experimental evidence, we obtain a curved line which incloses an area that represents, in a conjectural way, the real extent of what we know about matter. Thus, starting at —273 deg. Cent. or at the absolute zero, we have no experimental facts whatever and the line inclosing our area must begin at the bottom of the line of temperature. With a small rise of temperature our knowledge of the physics of matter increases rapidly. A number of facts are known at the temperature of liquid air, but it is at about 20 deg. Cent., at which temperature most laboratory experiments are tried, that our knowledge is a maximum. It then begins to fall off, slowly at first then very rapidly, until at 2000 deg. Cent. there are known relatively but very few facts and laws. Above this temperature our knowledge is very slight, being confined chiefly to radiation phenomena and the laws which govern the gravitation of matter.

This area, inclosed between the temperature scale and the limiting line of knowledge, may be called the *Region of Experimental Evidence*. It is the region in which our knowledge of matter rests upon the sure basis of observed facts and carefully made measurements. All outside of this area belongs to the field of imagination and speculation. It may properly be called the *Region of Pure Surmise*. The first region is large compared with that—shown inclosed in dotted line—which the philosophers of antiquity could have drawn to represent the knowledge of their day. But the second, the Region of Pure Surmise, extends beyond all assignable limits.

It is the inheritance and the pride of our generation that we can claim so great an extension from the region of the unknown. By the application of the scientific method, the invention of instruments, and the co-operation of many investigators, the insignificant area which may be assigned to the ancients, in a few generations, has been immensely enlarged. But we cannot rest satisfied, for the craving of intellectual man is to ever explore. Nevertheless, in this exploration we should seek intellectual efficiency quite as much as we strive for commercial efficiency.

To enlarge the region of experimental evidence our explorations should be directed where results will follow in greatest abundance for the efforts put forth—and, we should add, where the knowledge gathered promises to have an immediate or early application to the use and comfort of mankind in general. A glance at the shape of the area of experimental knowledge will show that it needs to be squared up in the temperature-range from 100 deg. Cent. to 2000 deg. Cent. Here lies the opportunity of the ambitious investigator to gather precise experimental knowledge of the properties of matter, now totally lacking, at temperatures which we can produce, control, and use industrially.

When the properties of matter are known in this region as they are now known between 0 degree and 100 deg. Cent. we may expect industrial uses of the properties of matter of vast and undreamed of service to man.

But the labors of a single individual are brief and very small. Even the well directed and long life of a talented investigator can only put, as it were, a fringe of differential breadth upon the margin of knowledge which is grounded securely upon experiment. But though the extension is slight the intellectual pastime which accompanies the effort is delightful. To accomplish as much as possible in a life time we should give careful heed to plans, methods, and equipment. A canvass of these leads me to believe that it is far more efficient for individuals to examine, study and measure a few important properties of many substances over a considerable range of temperature than to try to do the same for many properties of a few substances. In the former case the same general equipment of apparatus and the experimental experience acquired will be of service, whereas in the latter case many kinds of apparatus, a wider knowledge and a greater expense would be needed to accomplish an equal result.

Of the many properties of matter which deserve investigation, between room temperature and 2000 deg. Cent., the electrical conduction of matter is a problem which is at once definite and important. As the conduction of matter has interested me, I may be allowed to very briefly consider it here. In the region of temperature at which air is liquid, all bodies are divisible, very sharply, into conductors and insulators. At this temperature the resistivity of all the pure metals is extremely low, the curves all pointing toward zero resistivity at the absolute zero of temperature. The resistivity of the alloys is also low though not so low as that of the pure metals, and the curves do not point toward zero resistivity but above this value at the absolute zero of temperature. The ordinary insulators, on the other hand, are much more perfect insulators at very low temperatures than they are at room temperatures. Ice, for example, is an excellent insulator long before reaching the temperature of liquid air. The dielectric properties of the insulators, including ice, are extremely good at low temperatures. By good, it is meant that they show very little energy loss per cycle per cubic centimeter per volt when tested with alternating current. It is in fact a safe prediction to state that at the temperature of liquid air all dielectrics, as mica, glass, hard rubber, celluloid, fiber, etc., will not only show an extremely high resistivity, but also very little dielectric loss or electric absorption when used in a condenser.

As the temperature rises the so-called insulators diminish in resistivity. Thus Somerville, who has investigated the variation in resistance of glass, porcelain, and quartz, states that these substances begin to decrease in resistance at a very definite temperature and fall rapidly, so that in the small range of temperature from about 500 degrees to 1000 deg. Cent., the resistance may fall to 1/10 or less of its value at the lower temperature. Also some rods of pottery which measured 10,000,000 ohms at about 550 deg. Cent. measured only 15,000 ohms at 1100 deg. Cent. The course of the resistance curve with rise of temperature of an insulator is most familiar in the case of the Nernst glower, which is a good insulator cold and a very good conductor when white hot. The pure metals, and for the most part the alloys, on the other hand, steadily rise in resistivity as the temperature is increased from the lowest attainable to their melting points. At the moment the

metals melt they take, as it were, a leap in resistivity. Thus I have found, myself, the ratio of the resistivity after fusion to the resistivity before fusion to be: 1.45 for sodium, 1.52 for potassium, 2.28 for aluminium, roughly 2.5 for copper, 1.98 for cadmium, while investigations, now under way, indicate similar ratios for other metals. Other investigators find the ratio for tin 2.38, for zinc 2.1, for cadmium 2.3 and for lead 1.9. Two German investigators, J. Koenigsberger and K. Schilling, have made a thorough investigation of such half metals as silicon and titanium, and various oxides and sulphides of the metals. They found in general that the resistivity of these at first decreases, until a minimum is reached, and then continues to increase up to the highest temperature reached in their experiments, which was about 900 deg. Cent.

It is highly probable that at very high temperatures there ceases to be any distinction whatever between insulators and conductors. Electric conduction is now recognized to be of two kinds: electronic, or conduction by the passage of electrons, in which no chemical decomposition is produced, or counter electro-motor forces developed, and electrolytic conduction, in which there is chemical decomposition which at room temperature obeys the law of Faraday. As the temperature is elevated there is good evidence to show that in many substances both kinds of conduction can be taking place at the same time, and it is not known if all conduction may not be electrolytic in all compounds at elevated temperatures, and if so whether or not Faraday's law is obeyed.

Though we may already trace in general outline, the progress in these modifications in the electrical properties of matter as the temperature is elevated beyond 1000 deg. Cent. we have few exact data, or anything which deserves the name of precise measurement. The experimental difficulties are great, but great also is the need of precise information. We want it to reduce to a more exact science electric furnace practice and electrometallurgical operations. Quite recently Mr. L. Saunders has made a most commendable effort to determine the temperatures in the interior of a silicon carbide furnace, and has found the decomposition temperature of silicon carbine to be in the neighborhood of 2240 deg. Cent. But we want this information for, what in my judgment, is a far more important purpose, which is, to give an enlargement to our vision of the cosmos in which we dwell as men and not as mere money accumulating machines. For processes and machines should serve the spirit of man—the last and highest product of evolution—and this spirit must not be sacrificed to its servants.

The goal is to ever extend the region of *experimental evidence* and take a little more from the unlimited region of *pure surmise*. Every one that labors with earnest endeavor and honesty of purpose to improve apparatus, to perfect processes, to build machines, or to study pure science, in laboratory or field, is taking his mite, in the ceaseless conquest, from the region of pure surmise.

Some Japanese Scientists*

Prominent Figures in the Renaissance of the East

The dawn of modern science in Japan was somewhat late, but when the sun of knowledge once began to rise, it shone with a brilliance unprecedented among the nations. During the past fifty years Japan has made more progress in science than the whole world had made during the previous two thousand years. True, Japan cannot claim to be the mother of the scientific system she has acquired, for she received it readymade from the nations whose investigators had through long ages arrived at the sum of modern knowledge; but Japan's ready reception of the scientific attainments of the West, and her immediate utilization of them as to the manner born, place her on a plane far above China and other nations, who, in spite of opportunity, have remained for the most part ignorant of modern knowledge.

The tiny loophole through which the first rays of accidental light began to peer into Japan was the little Dutch settlement of Deshima at Nagasaki. As soon as the Japanese began to realize that the strangers were possessed of a knowledge much to be desired, the eager youth of Japan commenced to flock thither to investigate; and it is surprising how much of scientific fact these typical Japanese minds were able to elicit from mere merchants who laid no claim to be teachers of science. There were, of course, some men of intelligence and scholarship among the Dutch traders at Nagasaki; men like Von Siebold, who were capable of imparting to inquiring minds most of what was then known of science in the West. But the knowledge acquired by the Japanese from the Dutch amounted to little more than certain isolated but important truths, which served more to excite still greater curiosity than to be of much practical value.

These young Japanese pioneers of knowledge had to learn the Dutch language before they were in a position to acquire even the modicum of science then at their disposal. Among the earliest of these men, so representative of Japan, was Aoki Bunzo, whose eager thirst for knowledge led to his mastery of the Dutch language and his knowledge of the science of botany as then known to the West. Some time about the year 1734 he cultivated a small garden of foreign plants in Koishkawa, Tokyo, and gave himself up to their study in a manner thoroughly representative of the Japanese scientist. Later, Hiraga Gennai, a man of Sanuki, came in contact with the Dutch at Nagasaki, and obtained a sufficient knowledge of natural science and physics to be able to conduct successfully experiments in electricity, and to make electric machines and thermometers. The whole system of Western science did not come to Japan until about the year 1877, when teachers began to be imported from abroad, and Japanese students were sent to foreign universities and seats of learning in England, America, and Germany.

One of the greatest of Japan's pioneer scientists was Ito Keisuke, born in Nagoya in 1803, the son of a doctor of the old school. Even from childhood young Ito had been fond of making botanical collections, with a truly Japanese love of flowers. In 1827 he journeyed to Nagasaki to pursue his studies there under the instruction of the great Von Siebold. On completing his studies he traveled all over the Empire, exploring the highest mountains, and penetrating the most remote places in search of botanical specimens; and after twenty-eight years of this sort of study he was appointed Professor of Botany in the Imperial University. The discoveries Ito made were considerable, and so attracted the attention of the scientific world that at the International Geographical Conference, held at Rome, he was awarded a medal for his book on the Plants of Japan, and his own university gave him the degree of doctor of science. After a long life devoted wholly to his favorite science, he passed away at the age of 100 years.

Another name that will stand out forever among the scientific leaders of Japan is that of Yamakawa Kanjiro, who was born in Aizu in 1854, studied engineering in Russia in 1870, and graduated in physics at Yale University in 1875. Yamakawa became a professor in the Imperial University on his return to Japan, and did so fundamental a work there that he is now regarded as the father of physical science in this country. He finally became president of the University, from which he was recently transferred to a similar position in the new University of Kyushu.

Another name of illustrious merit among the scientists of Japan has attained eminence in the realm of mathematics; we refer to Kikuchi Dairoku, now Baron Kikuchi, late President of the Imperial University of Kyoto, and recently made a member of the Privy Council. Baron Kikuchi was born in Tokyo in 1855, the son of a Dutch scholar. He entered Cambridge University, England, in 1867, where, after five years, he graduated with the degree of B.A., taking a first-class in mathematics. Upon his return to Japan he wrote many textbooks in mathematics, which are widely used in the schools of the Empire. He received his M.A. degree from his Alma Mater in 1881, and has since been elected member of many learned societies.

Nagai Nagayoshi, the great Japanese pharmacologist, was born in Awa, 1845, educated in Germany, and afterward appointed a professor in the Medical Department of the Imperial University, Tokyo. Another scientist of more than national fame is Teroa Hisahi, whose research work in the department of physical science is worthy of notice. Dr. Terao's most noted achievements are in the realm of astronomy. As he had studied in France, he was sent out with the French expedition for observation of the planet Mars on the island Martinique; and after his return to Japan he made informing reports of his work, and was placed on the commission for the determination of the meridian. He is at present Professor of Astronomy in the Imperial University, Tokyo. Sakurai Joji studied at the University of London, where he won a scholarship of £100, and on his graduation was appointed a professor in the Tokyo University. His special field is chemistry, in which he is regarded as the highest authority in Japan. Kato Bunjiro is a noted specialist in geology. He is a distinguished graduate of the University of Leipsic, and at present a professor in the Imperial University, Tokyo. His geological theories, as to Japan, have attracted the attention of the world's scientists.

In the Department of Zoological Science the name of Mitsukuri Kikichi will be ever long and favorably remembered. A younger brother of Baron Kikuchi, he studied in America, where the first to offer him hospitality was the celebrated humorist, Mark Twain, at whose house he stayed, in company with Prof. Kojima, now professor at the First High School, Tokyo, when the two young men first went to the United States. Mitsukuri took his bachelor's degree at Yale University, and a post graduate course at Johns Hopkins University later. He further prosecuted his studies in zoology in Great Britain at Cambridge, after which the University at Baltimore made him a Doctor of Science. His achievements in the realm of zoology were of worldwide repute, and when he died last year, the Imperial University lost one of its most noted men.

The name of Kuhara Mitsuru is wide and favorably known in the work of organic chemistry. Dr. Kuhara was educated in Johns Hopkins University, with post graduate courses in Germany, where he made great advances under the famous Prof. Remsen. In an article published by him in the *Chemical Journal* of Johns Hopkins University, he pointed out mistakes made by celebrated chemists, and not only astonished the world by his knowledge, but added much light by explaining his experiments in the field of organic chemistry, especially in relation to bismuth and sulphur. His thesis for the degree of Doctor of Philosophy was on the subject of Mineralogy, with Chemistry for a major. He has recently been appointed President of the Imperial University, Tokyo.

Sasaki Chujiro received his first inspiration toward science when he was a student in the Tokyo Imperial University under the American, Prof. Edward Morse. Later he took up the study of sericulture, and prosecuted his studies in Germany and France, and he is to-day recognized as one of the greatest Japanese authorities on silk culture.

Dr. Sekiya Kyokage has become an authority on seismic and volcanic phenomena in Japan. He studied in England, as well as in the Tokyo University, and after taking up work at the latter institution, he invented a seismometer, and established the first college of seismology the world has seen. At the British Association meeting for the Advancement of Science, a Swiss professor declared that Sekiya's work in the realm of seismology exceeded all that had been done in other countries. Since his lamented death, his work has been worthily carried on by his scarcely less famous pupil, Dr. Omori.

In the field of botany the name of Matsumura Ninzo has won deserved fame. Dr. Matsumura studied in Italy; and in Germany he won a name for high scholarship as a student of Prof. Fitzel. On his return to Japan he became a teacher in the Imperial University; and his books on the science of botany have won wide attention. Yokoyama Matajiro is a great authority in the department of geology and archæology. He was educated in the Imperial University of Tokyo and in the University of Munich. After an extensive study of the various districts of Europe, he 'nd fi back to his native country, where he has since been a noted teacher in his special field.

Iijima Kwai is another brilliant son of the Imperial University, Tokyo, who owes his first inspiration to Prof. Morse. As an under-graduate, he wrote a dissertation on his experiments with the leech, which attracted much attention, and was thought worthy of publication in foreign journals. He went to prosecute his studies further in Germany, where he won the esteem of many great names in science, and received a gold medal from the King of Saxony. He is now a leading authority on ornithology in Japan.

In the realm of physics and acoustics the name of Tanaka Schohei holds an honored place, not only in Japan, but in Europe. During his studies in Berlin, he invented an apparatus for upright pianos, for which he received a patent from the German Government, and was accorded an audience by their Majesties the Emperor and Empress of Germany; and the Prussian Government requested him to affix his invention to the great organ in the cathedral at the capital.

Dr. Tanakadate, the noted authority on electrical science, is a graduate of Glasgow University, where he had the honor of being elected president of the Philosophical Society. After post graduate work in Germany he returned to take up duty in the Tokyo University. He is now an authority on the art of dying and barometric pressure. There are many other names in the realm of science among the Japanese; but, as we said at the outset, space forbids even the mention of them.

*From the *Japan Magazine*.

The San Joaquin Hydro-electric Power Installation

By F. C. Perkins

The hydro-electric power station, reservoir and water shed of the San Joaquin Light and Power Company of the Southern California Hydro-electric Development may be noted in the accompanying illustrations. The photograph Fig. 1 shows the interior of power house No. 3 while the frontispiece and Fig. 2 show some of the flumes, tunnels, and conduits. The reservoir, which appears in Fig. 3, holds 50,000 acre-feet when full, with 2,170 feet fall through the conduits of the three power houses. A dam was constructed in the path of the North Fork of the San Joaquin River, where it widens out to form Crane Valley to conserve the winter waters, that they might be used in the third power house, again in the second plant, and finally in the old original plant.

Directly back of this dam of hydraulic construction are impounded 4,300 acre-feet of water during the wet months, to produce a sufficient flow for the 4,600 horse-power equipment.

Enlargements of the system since this dam was built have necessitated the construction of a new and larger one. This solid concrete structure cemented to the bed-rock fortunately on the surface at this point, just below and adjoining the present dam, forms a new lake 150 deep at the dam, and owing to the very level nature of the floor of Crane Valley, an extensive mountain meadow, the water extends for five miles up Crane Valley, or up the valley of the North Fork, and aggregates to 68,000 acre-feet when filled according to the design of this reservoir. There is thus conserved enough water to supply a power house capacity of 17,314 kilowatts delivered to the line in the three houses below, when the South Fork water is emptied into the reservoir. Below the canyon from the Crane Valley dam the conduit extends for 4.22 miles, with a width of 5 feet at the bottom along part of its length, the remainder being 6 feet in width, both parts being 3½ feet in depth and trapezoidal in cross section, with 45-degree slope at the sides. The grade of the narrower section is 0.15 foot per 100 feet, while the wider section conduit slopes 0.1 foot per 100 feet.

The ditch thus formed is in a substantial bed of disintegrated granite for the greater part of its length, and is plastered with cement. The capacity is 100 second-feet when running 3 feet full. There are four tunnels on this line 5 feet wide and 6 feet in height on a grade 0.3 foot per 100 feet.

The flumes are thirteen in number and consist of semi-circular steel of 3-foot radius. An interesting problem had to be faced in taking care of changes of temperature in the steel flume, which were considerable owing to the large difference between the summer and winter and the night and day temperature, with a small flow of water in the day time, when the temperature is high. Canvas "expansion joints" have been found a simple and inexpensive solution. The profile of the country in this canyon may be appreciated from the fact that the tunnels and trestles combined comprise 27 per cent of the total length of the conduit.

There is a lake of considerable proportion above No. 3, containing 33 acre-feet or a four hour's supply of 100 second-feet for regulating purposes and in case of accident on the conduit line. It is pointed out that this form of reservoir is exceedingly useful in California water powers, where small quantities of water are used under high heads.

A uniform flow in the conduit line from the Crane Valley reservoir is conserved in this regulating reservoir to accurately fit the conditions of load or any emergency overload over the lighting peak in the power house below.

There is provided a bank of lamps in the third power house operated in conjunction with a float in the reservoir, and so connected that the lamp burning indicates the number of feet of water in the reservoir 3,000 feet away. As the water falls, one after another of the lamps are lighted every time an even foot is passed.

The water from regulating forebay reservoir is taken into the pressure pipe line through a tunnel 20 feet below the overflow grade line, the upper end of the pipe consisting of a taper fitting 20 feet in length, being under the full pressure of the depth of water in this reservoir. The pipe has a diameter of 52 inches and is divided into seven sections varying from 170 feet to 1,141 feet in length with suitable valves for relief, in case of water hammer, the pipe being covered with 1½ feet of earth and with massive concrete anchored at proper intervals.

At the third power house, without the introduction of a receiver, the water issues from the four 6-inch needle-regulating deflecting nozzles to impulse wheels. Two of these wheels are connected to each of the two 1,000-kilowatt, 550-volt, 300 revolutions per minute, 60-cycle, 3-phase alternators, which feed solidly into the transmission line without protective devices, through non-automatic oil switches and disconnecting line switches. The generators are Y wound, the neutral being grounded.

The transformers are each in a separate concrete cell, placed in a concrete addition to the main building, also of concrete with steel-trussed roof. There are gages which enter the generator room, showing the height of oil and indicating any leaks in the water-cooling system.

Provision is made for a flooding system, admitting water under high pressure to the bottom of each transformer case in case any transformer should give serious trouble. Leakage from this system into the case under normal conditions is prevented by using two gates into each transformer flooding tap, a tiny hole to indicate leakage in the first gate being provided in the bottom of the pipe between the two gates.

One of the cells contains the lightning arresters, of the General Electric zigzag, non-arcing, metal type, with series carbon resistance which are used throughout the system. It is said that they have taken care of lightning discharge in a most perfect manner.

Fig. 1.—Interior of the Third Power House.

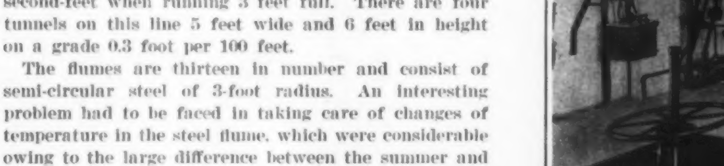


Fig. 2.—Flume and Conduit for the Second Power Station.

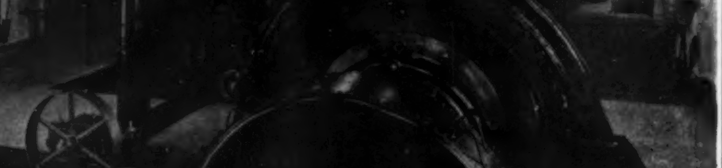


Fig. 3.—Reservoir Feeding the Three Power Houses.

The water is discharged into the river bed of the North Fork from the tail race of power house No. 3, whence it flows to the intake of the other power houses at the junction of the North Fork and South Fork.

The pipe line down the Rocky Mountain side, 1,411 feet below, is 4,007 feet in length, consisting of four sections. The whole is terminated with a 30-inch receiver 57 feet in length, constructed of ¾-inch butt strap riveted steel with ¾-inch rivets. The pipe is buried various depths with the exception of the expansion joints, which require inspection, especially at the first real approaches of winter and summer. The pipe is anchored to the solid granite by means of 2½ x ⅝-inch U-bands, with split rods sulphured into the bedrock, besides many cement-collared anchors. The original power house was put into operation more than a decade and a half ago when the water was turned on the first wheel, at 609 pounds pressure, at that time the highest head known. The needle regulating nozzle was not in use at that time. The deflection regulating 1½-inch nozzle, installed in the plant originally, may be seen in the scrap heap at the back of the power house.

Since the first power house was installed, there has been added to the three 350-kilowatt 60 cycles, 700-volt, 600-revolutions per minute General Electric generators a similar 360-kilowatt machine of a more recent construction while the old air-ventilated transformers have been replaced by six 200-kilowatt General Electric air-blast transformers, cold air being taken from the tail race tunnel for the blast.

Later four 200-kilowatt oil-filled water-cooled transformers were installed, forming a three-phase set with one reserve. These are provided with a Lombard-Replogle mechanical governor and a Tirril regulator to keep variations of speed and voltage to a minimum. Kellman oil-break switches and a double set of busses are used to switch the three circuits into any desired combination. The generators were not provided with fuses or circuit breakers, being connected solidly into the line.

A 30,000-volt line of three No. 0 wires extends 7½ miles to the original power house. The pine poles were supplied in the immediate vicinity and no attempt was made to put them in the ground, on account of their quick decaying qualities. Stubs 10 inches square and 10 feet long were sawn from the heart of fall-cut cedar, which grow in lesser numbers in the neighborhood. To these stubs, by means of two ¾-inch U-bolts and armature, the pipe poles were bound.

Several years of service have developed no trouble. This line enters the old original power house through an oil switch to a double set of busses, connecting with these busses also are the leads from the step-up transformers of the old power-house so that the current from the third power station as well as that coming from within No. 1 may each be switched to either of the duplicate lines down in the valley.

From this power house two transmission lines extend southward to a point where the fertile valley meets the rocky foothills. A copper mine here derives its power from transformers in a small sub-station near the switching-engine station. The switching station is located at the beginning of the distribution of power. The duplicate lines from these power houses, the line skirting the valley to Madera, and those over the floor to Fresno, Corcoran, and Cottonwood Creek, may be switched each to the other as desired.

The poles between the first power house and Fresno are cedar and this line required little stubbing. Long span work has been used, with success, under the mild climate conditions of this section.

Every other pole of the original line has been removed between Clovis and Fresno, making the spans 240 feet wide while the line to Madera from the Clovis switching station is composed of 250-foot spans. The line from Fresno to Kerman of No. 6 wire has its spans 350 feet in length for 12 miles, and 250 feet long for the five miles nearest Kerman. For many small branches of the 4,000 to 6,600-volt lines iron wire with 500-foot span is common.

Industrial Developments in India

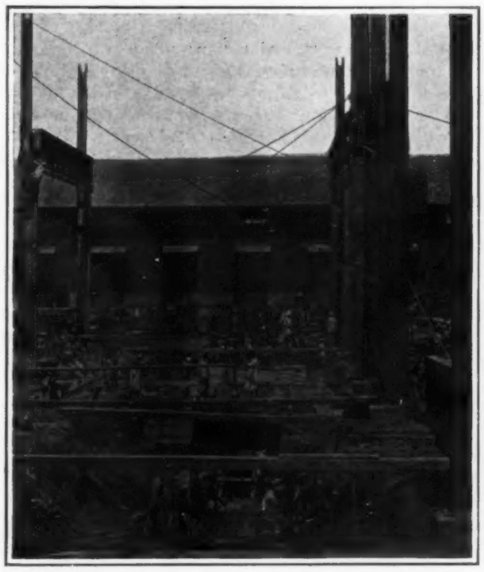
American Enterprise on British Soil

By Hartley M. Phelps

An undertaking has just been completed in India that marks the inauguration of an industrial and economic *régime* fraught with incalculable possibilities for its three hundred millions of inhabitants. Unless all signs fail it means a revolution in the working and living conditions of the crystallized caste-bound myriads who, for centuries groaned under the despotism of the Moguls. In a word, it means the grid-ironing of the vast country with railroads; the development of its great iron, coal and timber resources; and the freedom of its natives from penury and periodic famine. India, like China, Persia, and Asiatic Turkey, has taken the first step toward joining the ranks of the modern industrial nations.

Four years ago Mr. W. B. Renkin of Pittsburgh, Pa., went to India to superintend the construction of an iron and steel plant for the Tata Iron and Steel Company; the plans for which were drawn by Mr. Julian Kennedy, the eminent mechanical engineer and inventor—also of that city. Several weeks ago Mr. Renkin returned to this country, having concluded his task. The story of his labors in the jungle: how he not only trained the ignorant, superstitious natives to do the manual work of mill construction but provided for the feeding, housing and health of 20,000 persons, suddenly brought into the mill district: and in the meantime overcame superstition and prejudice on the natives' part and surmounted the obstacles of caste, the curse of India—is a vivid lesson in Anglo-Saxon pluck, energy and initiative. It suggests—or rather exemplifies—Kipling's famous saying of the "White Man's Burden."

The works of the Tata company are near Kalimati on the Bengal-Nagpur Railroad, 155 miles from Calcutta, and comprise: blast furnaces, open-hearth steel furnaces, blooming and merchant mills, rail-finishing department, foundry, coke oven and gas-producer plants, boiler house, power house, pumping station, store house, etc. The two blast furnaces have a combined capacity of 120,000 tons of pig a year; 75,000 tons of which are to be made into steel rails, and 35,000 tons into pig iron. Standard sections in rails up to 75 pounds are to be turned out. The merchant mill will make shapes up to 12 inches, I-beams and channels, and six-inch angles, flats and rounds.

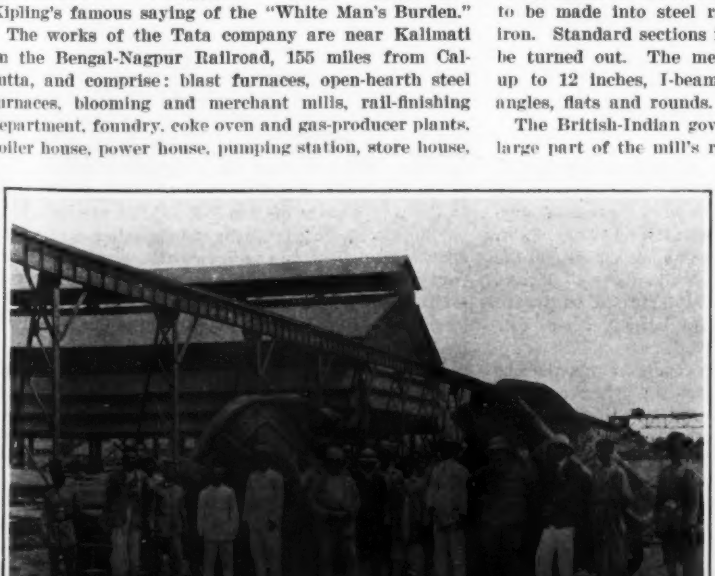


Natives Working on the Foundations of a Mill.

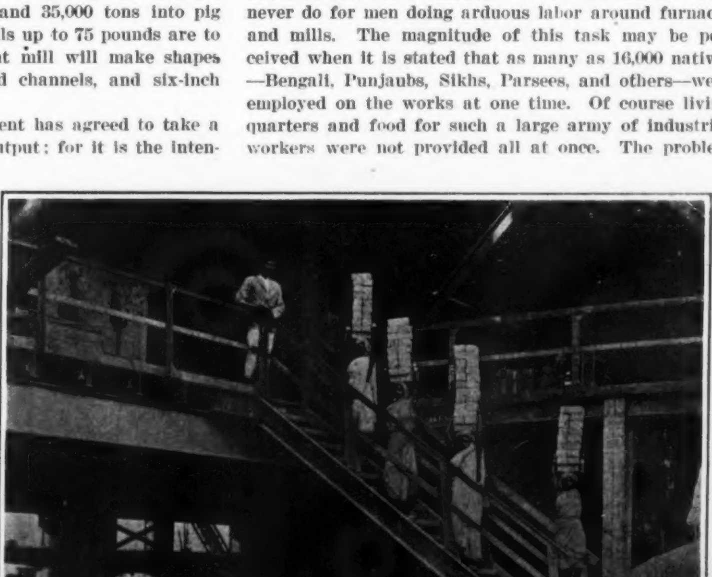
The British-Indian government has agreed to take a large part of the mill's rail output; for it is the intention to start extensive railroad projects to open up the rich agricultural and mineral lands. The Tata company gets its coal from its own coal fields at Jherria, 110 miles from the plant; and its iron ore is pure Guiramasini from the State of Mayurbhang, 90 miles away; which deposits were discovered by C. Minot Weld, a mining engineer of New York. It is estimated that there is sufficient ore to last 5,000 years.

Mr. Renkin had scarcely set foot in Kalimati before he saw—somewhat to his dismay—that the work for which he had been engaged; the construction of the plant, would have to be vastly added to along lines he had not anticipated. A teeming jungle confronted him; and within the twenty square miles leased by the Tata concern were no civilized communities. Nothing but a score of villages of thatched huts, with walls of sun-dried brick, in which lived about seven hundred natives. Theirs was the simple life. A little rice and lentils sufficed them for food; and they donned as few clothes as possible. There was absolutely no regard paid to sewage or health, and he was informed that cholera stalked abroad in the summer months and smallpox in the winter.

Something had to be done—and nobody knew just how to do it except Mr. Renkin. But his American pluck and determination to "make good" now showed itself in a new light; and, forming a staff of assistants, he proceeded to procure funds with which to build sanitary abodes for the workmen he had to have. Mud-floored huts, and a handful of rice and lentils would never do for men doing arduous labor around furnaces and mills. The magnitude of this task may be perceived when it is stated that as many as 16,000 natives—Bengali, Punjaubs, Sikhs, Parsees, and others—were employed on the works at one time. Of course living quarters and food for such a large army of industrial workers were not provided all at once. The problem



The Constructing Engineer and His Native Staff.



Some Women Coolie Workers at the Mill.

The Tata Iron and Steel Works.

had to be solved by degrees. And big and portentous it was, involving provision for twenty to twenty-five thousand men, women and children within a district where only seven hundred had formerly lived.

To add to his labors Mr. Renkin had to study and familiarize himself with the strange inflexible rules of caste governing his workmen. For in India natives of particular castes may only do certain kinds of work; to perform other work would involve loss of caste, which is worse than death with them. It was, as he said, not so much a problem of learning what a native could do as what he could *not* do.

Then there was the question of languages. Like the men who builded the Tower of Babel Mr. Renkin's workmen spoke no less than forty tongues. Of course it was beyond possibility for him to learn, even in a fragmentary way, two score of languages, but he did master three or four sufficiently to make himself understood on the work.

The absence of telegraph and telephone service made it necessary to organize a corps of uniformed messengers or Chaprasies, the men being selected from castes which permitted them to perform such work. In order to cover the long distances he was obliged to go frequently (Mr. Renkin was much in the saddle) sometimes traveling from fifty to two hundred miles, for there were neither railroads, street cars nor public conveyances. India is thinly settled except in the large cities, and along the sacred Ganges; and the jungle extends to within twenty miles of Calcutta, a metropolis of the East with one million inhabitants.

In fact so exceedingly busy was the ruling spirit of all this activity that for two years he worked seven days a week, snatching only four or five hours' sleep out of the twenty-four. During this time practically all the manual work on the company's property was done by natives; some of the educated ones—called "babus"—serving as engineers, surveyors, foremen, and in other capacities. For many months Mr. Renkin and his wife were the only white persons within a radius of fifty miles.

The natives proved themselves good and efficient workmen, sober and industrious; but, of course, they had to be shown how to do things after the western method. While small of stature as a rule they were strong and capable of great endurance. This extended to the women as well as the men; and quite a number of bronze-hued fair ones carried big piles of brick and heavy timbers on their head. When the great dam, 2,500 feet long and 57 feet high was built across a creek near the plant, these women helped to carry part of the six million cubic feet of earth used to form it. One hundred and eighty barrels of cement a day were utilized in building this work. The dam forms a portion of a cooling tank to which water is pumped from the Subarnarekha river (meaning "Level of Gold").

The first and most important work that had to be done was to provide food for the great number of men engaged on the work and their families.

A coolie staff was organized to do this; and one of their duties was to recruit workmen. Credit for supplies had to be established, which was not easy as much prejudice exists in India against business.

The homes for the natives in the town were built along western lines, tile roofs being used instead of thatch, and running water from the river put in each house so the various castes could wash and bathe without pollution. The caste rules proscribe one caste bathing in the same river or water as another. Modern drainage was initiated, a sanitary staff of five hundred persons being formed. By this work cholera, one of the scourges of the Indian summer—and also smallpox, prevalent in winter—were eliminated.

Mr. Renkin also established a hospital and although the natives at first called it the "Devil's Home" and regarded the head physician as His Satanic Majesty's agent, this superstition passed away. Now one hundred cases a day are being treated there. The hospital has a full-fledged staff, including a native doctor, who is a graduate of the Calcutta Medical College; and a corps of trained nurses from the Albert Edward Hospital at Poorna.

Besides these works a school was established where there are now forty-three pupils, three of them girls under seven years of age. When girls attain that age in India they are secluded.

It was necessary of course to have a police force for so large a community, so Mr. Renkin organized a corps of private guards for the Tata company. These men are ex-soldiers. To facilitate his executive functions and add force and dignity to his decrees he became a magistrate under the British law, and also joined the Chota Nagpur Light Horse of the British Army. It is believed he is the only American citizen who has held posts in both of these and at the same time not relinquished his citizenship. Chota means "Little City of the Snakes."

Mr. Renkin says that the natives are simple-minded but are a kindly happy-go-lucky lot and contented. With true Oriental fatalism they simply shrug their shoulders if one of them dies and comment calmly, "Kismet," meaning fate. They are of the old jungle tribes described by Kipling. Each family has its own household gods: crude images in stone or metal; and each town has its chief, who protects the citizens from outside thieves.

It was necessary to have a law passed to enable the company to acquire freehold title to the five square miles of land on which the plant is built. The negotiations pertaining to this were conducted by Mr. Renkin. The land in India is owned by the government, and is rented out to the natives for a small tax. Mr. Renkin says the English there are fine men to deal with, as they are honest and upright, and men of their word. The natives take their disputes to the government officers in preference to going to law.

The Tata Iron and Steel Company was founded some years ago by J. N. Tata of Bombay, a rich Parsee. After his death his two sons took charge of the enterprise and have carried it to completion. The Parsees, it may be observed *en passant*, are the descendants of the ancient fire-worshipers of India; who venerated the (supposed) four elements of Nature: earth, air, water, and fire. J. N. Tata foresaw a great future for his native country in the iron and steel business. In this connection it may be said that Mr. Renkin believes there is immediate need for the establishment of two more plants similar to and equal in capacity to the Tata works.

Cold Storage of Furs and Fabrics*

The Modern Method of Preserving Goods from the Attacks of the Moth

By E. F. Tweedy

The placing of furs and such fabrics as carpets, tapestries, clothing, woolens, etc., in cold storage to protect them against insects during certain portions of the year, is now generally recognized as the most satisfactory method of dealing with this important problem. The annual loss arising from the destruction of the above classes of merchandise by the moth and the beetle cannot be even approximately estimated, but the yearly toll is unquestionably tremendous, and any means of reducing this loss is therefore worthy of serious consideration.

The first storage warehouse in this country to undertake the cold storage of furs, carpets and other fabrics was located at Washington, D. C., and provided cold storage facilities for goods in 1894.

For two years thereafter, Albert M. Read, assisted by Dr. L. O. Howard, chief of the bureau of entomology of the United States Department of Agriculture, carried on a series of extremely interesting and valuable tests to determine the effects of various temperatures upon the larvæ of the moth and beetle. These were probably the first tests ever conducted along similar lines, and the results secured served largely as a basis for the subsequent commercial development in the use of cold storage for the protection of furs and fabrics.

The cold storage of furs at first was opposed by many furriers, who had derived a considerable income from caring for their customers' furs during the summer months, such care usually involving a frequent brushing and shaking of the furs, separated by intervals during which they were packed away with camphor, tar paper or some other moth-repelling substance.

But such opposition gradually disappeared and to-day the leading furriers either operate their own cold-storage vaults or else rent storage space in cold storage warehouses. The latter are rarely so located as to be conveniently reached by the furriers' patrons, and this is doubtless the reason the majority of the furriers and department stores maintain their own refrigerated rooms for storing furs.

In the experiments referred to it was found that any temperature below 45 deg. Fahr. was sufficient to keep the larvæ of the moth and the beetle from doing any damage, although the larvæ were capable of sluggish movement at a temperature as low as 42 deg. Fahr. Below 40 degrees all movement was suspended and the larvæ became entirely dormant, while above 45 degrees activity of the larvæ began and increased with each degree up to 55 degrees when a normal, active condition was reached.

It was found that the larval condition was the one in which the damage occurred, as the grease and animal juices in the fiber of the fur and wool serve as food for both the moth and the beetle larvæ while these insects are passing through this stage. The larvæ, it was found, could withstand as low as 18 deg. Fahr. for a long period without harmful effects and they changed back from a dormant to an active condition when the temperature again became normal. However, if repeatedly exposed to considerable changes in temperature, the larval vitality was considerably reduced—a fact which should cause a winter composed of alternating periods of cold and mild weather to be followed by a summer of decreased insect life. Also that the miller and the beetle were soon killed when subjected to temperatures below 32 deg. Fahr. and that they gradually died if exposed to between 32 and 40 deg. Fahr.

While these investigations showed that cold storage rooms for preservation of furs and fabrics may be kept at 40 deg. Fahr. with perfect safety, the temperatures most commonly carried in cold storage rooms to-day range from 20 to 26 deg. Fahr. At these lower temperatures the furs retain a fresh and glossy appearance, and the flexibility of the skins is preserved by a lessening of the evaporation of their natural oils.

Two methods of applying mechanical refrigeration to the cold storage of furs and fabrics are in general use; one is the direct system and the other the indirect, each system possessing advantages as well as disadvantages. In the direct system the refrigerating coils—either arranged for direct expansion or for the circulation of brine—are placed within the storage room itself, being mounted upon the side walls or ceiling, or upon both. The indirect system comprises an all-cooling room or bunker space in which are the refrigerating coils, this space being entirely separate from the room to be refrigerated but connected with it by a system of ducts through which the refrigerated air is circulated by means of a fan.

The advantages of the direct system are that it is somewhat cheaper to install and also to operate: the first, because of the elimination of the air-cooling chamber and air-circulating fan, although this is partially offset by the somewhat greater cost of the piping for the cooling coils; the second, because it is unnecessary to operate an air-circulating fan, which requires an appreciable amount of energy. With either system, using brine as the cooling medium adds materially to the first cost of the installation, and likewise increase

* Reproduced from *Power*.

TABLE I. CAPACITY OF PLANT AND VOLUME OF REFRIGERATED SPACE.

Capacity, Tons Refrigeration.	Motor Drive Refrigerating Plant, Horse-power.	Contents Storage Space, Cubic Feet.	Cubic Feet Storage Space per Ton Refrigeration.	Square Feet Surface (Floor, Ceiling, Side Walls) per Ton Refg.	System.
50	..	155,000	3,100	...	Indirect—brine coils
20	35	60,000	3,000	748	Indirect—ammonia coils
15	25	40,500	2,700	651	Indirect—ammonia coils
10	15	32,700	3,270	805	Direct—ammonia coils
4	7½	5,720	1,430	569	Direct—ammonia coils

the cost of operation due to the necessity of constantly circulating the brine.

The use of brine arises from the fear of a leak in the ammonia piping, with a consequent damage to the goods in storage. Where the ammonia piping is carefully installed and tested before being placed in operation, danger from the leakage of ammonia gas is probably not great, as the successful operation of the large number of plants employing ammonia as the refrigerating agent bears witness.

However, in view of the heavy financial responsibility usually involved where furs in any quantity are held in storage, this question is of considerable importance, and where ammonia is employed as the refrigerating agent, the indirect system, with brine as the secondary cooling medium, offers the greatest amount of security against damage from the refrigerating medium itself. The indirect system is further advantageous in freeing the storage space of the moisture which collects as frost on the piping and which melts and drips from the pipes if the temperature rises above the freezing point. The air in the storage space is therefore drier where the indirect system is used; this is also an advantage, provided the percentage of moisture is not reduced too far, a condition which can easily be prevented.

One of the arguments advanced against the indirect system is that it involves an increased fire risk, as the movement of the air in the storage space might tend to fan a fire if one should occur. This belief was considerably strengthened by a fire, involving a heavy financial loss, which occurred in the fur cold storage room of a large department store in Brooklyn a few years ago. The origin of this fire was unknown, but it has been generally contended that the system of air circulation that was in use was responsible for the fire.

As a result, the New York Fire Insurance Exchange made certain recommendations as to the manner in which the indirect system of refrigeration for fur-storage rooms should be installed. These recommendations call for the air duct or ducts to be equipped with automatic dampers, arranged to be controlled by fusible links properly installed; the blower or fan to be equipped with an automatic controller arranged to be operated either by electric thermostats having a low fusing point, or by thermometers having proper attachments installed within the cold storage room, and that these devices be adjusted to operate the controller on the blower so that when the temperature rises to 100 deg. Fahr. the blower will shut down. Where these recommendations are observed, this system apparently offers no material increase in fire risk over the direct system.

The refrigerating requirements for given outside temperature conditions, and for a given maintained temperature within the cold-storage space, are, of course, directly dependent upon the insulation provided for the floor, walls and ceiling of the room to be refrigerated. As the insulation in different installations varies greatly in its effectiveness in limiting the passage of heat from the outside to the inside of the refrigerated space, it is impossible to even approximately estimate the refrigerating requirements for a given volume of cold storage space without a knowledge of the character of the insulation to be employed.

This is particularly evident when one considers that with some of the different combinations of insulating materials in ordinary commercial use variations may be obtained in heat transmission from less than 1 to nearly 5 B. T. U. per 24 hours per square foot of exposed surface for each degree of difference between the inside and outside temperatures. Table II shows the approximate number of B. T. U. transmitted per square foot per 24 hours for each degree of temperature difference for several different types of insulation commonly met with in practice.

The number of cubic feet of refrigerated space per ton of refrigeration naturally varies with the size of the space refrigerated, other conditions remaining the same inasmuch as the exposed surface through which the gain of heat occurs does not increase in proportion to the increase in the volume of the refrigerated space. It is also somewhat affected by the system of refrigeration employed; that is, whether the direct or the indirect system and whether brine is used as a secondary cooling medium. As in all other refrigeration problems this question of insulation is of paramount importance, and the saving in the cost of power required will almost invariably pay a large return upon the money invested in a high grade of insulation.

Table 1 shows the capacity of the refrigerating plant installed, the cubical contents of the space refrigerated, the volume of refrigerated space and the total exposed surface per ton of refrigerating plant capacity, together with the system of refrigeration employed, for a number of electrically driven refrigerating plants used in connection with the cold storage of furs and fabrics.

Table 3 gives some figures on power required for motor-driven refrigerating plants used exclusively for the cold storage of furs. In cases 2 and 4, the compressor motors were not separately metered prior to June, so that the kilowatt-hour consumptions for the preceding months were not available. In cases 1 and 3, the consumption figures cover an entire year, although these plants were in actual operation only during some seven or eight months.

TABLE 2. CHARACTER OF INSULATION

	B.t.u. per sq.ft. per 24 hr. per deg. dif. between outside and inside temp.
Double ⅞-in. boards and paper, 1-in. air space, 5-in. sheet cork, paper and ⅞-in. board	0 90
Double ⅞-in. boards and paper, 1-in. air space, 4-in. sheet cork, paper and ⅞-in. board	1 20
Two ⅞-in. boards and paper, 8-in. mill shavings, two ⅞-in. boards and paper	1.35
Same slightly moist	1.80
Same damp	2.10
Double ⅞-in. boards and paper, 4-in. granulated cork, double ⅞-in. boards and paper	1 70
One ⅞-in. board and paper, 3-in. sheet cork, paper, one ⅞-in. board and paper	2.10
One ⅞-in. board, 6-in. patent silicated strawboard (air cell), finished with thin layer of patent cement	2.48
Four double ⅞-in. boards with paper between (eight boards in all) and three 8-in. air spaces	2.70
One ⅞-in. board, paper, 2-in. sheet cork, two ⅞-in. boards and paper	3.00
Two ⅞-in. board and paper, 1-in. sheet cork, two ⅞-in. boards and paper	3.30
Two ⅞-in. double boards and two papers, 1-in. hair felt between	3.32
One ⅞-in. board and paper, 2½-in. mineral wool, paper and ⅞-in. board	3 62
Two ⅞-in. boards and paper, 1-in. air space, two ⅞-in. boards and paper	3 71
One ⅞-in. board, 2-in. pitch, one ⅞-in. board	4 25
One ⅞-in. board, 1-in. pitch, one ⅞-in. board	4 90

It is somewhat surprising to observe how low the load factor is in these plants, even during midsummer. Based on the rating of the motor which drives the compressor, plant 1 operated at rated load for only 10 per cent of the time during July, the month of greatest consumption; while for the entire period (May to October, inclusive) it operated at its rated capacity only 6½ per cent of the time.

Upon the same basis, plant 2 showed a 30 per cent load factor for September and a 27 per cent load factor for the seven months ending with December. Plant 3 had a load factor of 16 per cent during June, and a load factor of 12 per cent for the period beginning with March and ending with October; while plant 4 had a maximum load factor of 21 per cent during July, and 16 per cent for the seven months ending with December. The load factor thus based upon the rated capacity is, of course, dependent upon the relation of the size of the plant to the actual refrigerating requirements.

While it is quite usual to provide refrigerating capacity sufficient to permit the plant being closed down during 12 or 14 hours out of the 24, even at a time when the refrigerating requirements are at a maximum, it would appear that all of these plants, with the possible exception of No. 3, have capacities considerably in excess of those actually needed to meet present requirements.

It is somewhat difficult to accurately predict what the consumption of electrical energy will be for a proposed fur-storage plant unless there is detailed information as to the character of the insulation to be employed and unless the type of refrigerating plant that is to be installed is known. The method of operation will also affect the consumption materially, as, for instance, whether manual or thermostatic control of the compressor is employed. From an examination of the data given in Table 3, it would appear that the kilowatt-hours per square foot of exposed surface (including floor, ceiling and side walls) varies, for these particular plants, from a little under 1 to about 3, this variation being due not only to the character of the insulation employed but to the type of plant and to the method of its operation.

The operation of plant 3, in Table 3, is briefly described as being typical of the modern fur-storage plant. It is operated about eight months of the year, usually from March 1st to November 1st, but sometimes for a longer period, according to the weather conditions. The storage vaults contain about 60,000 cubic feet, and about 15,000 fur garments are stored during the summer months. The ammonia expansion pipes are located in a cooling room containing approximately 2,700 cubic feet. A system of ducts connects this room with the cold storage vaults, and the air is kept in circulation by means of a blower operated by a 4½-horse-power motor.

Brine is allowed to trickle over the ammonia pipes to keep them free of frost, and its circulation is effected by means of a 1-horse-power motor-driven centrifugal pump. This brine is not employed as a secondary cooling medium, as in the brine system proper, but simply for the purpose stated. In thus keeping the external surfaces of the cooling coils free from frost, the transfer of heat from the air of the cooling chamber to the expanding ammonia gas within the coils is facilitated and the operating efficiency is thereby increased.

After the plant is started in the spring and until it is shut down in the fall, the temperature in the storage vaults is never allowed to rise above 32 deg. Fahr. During this period the average temperature is approximately 20 deg. Fahr., ranging from 26 degrees in the early morning to about 14 degrees just before the plant is closed down in the afternoon. From 6 P. M., when operation is ordinarily discontinued, until 8 the next morning, when it is usually started again, the rise in temperature is about 12 degrees. On Monday mornings, the plant having been shut down over Sunday, the temperature is generally about 30 deg. Fahr.

The storage vaults and the cooling room are well insulated. The floor insulation consists of 1 inch of paving cement, two 2-inch layers of cork, a layer of felt, 6 inches of ordinary cement and finally 3 feet of slag cement. The ceiling comprises ½ inch of plaster, four 2-inch layers of cork, a 4-inch air space, and above this a layer of firebrick. The walls are composed of firebrick with cork insulation embedded in tar. From the actual kilowatt-hours consumed during the summer months, taken in connection with the recorded mean temperatures of the outside air during the same period, it would appear that the average loss through the floor, ceiling and walls of this vault is approximately 1.25 B. T. U. per square foot per 24 hours per degree difference in temperature, which shows that in point of fact a very high quality of insulation has been provided.

TABLE III. POWER REQUIRED BY COMPRESSORS OF VARIOUS CAPACITIES.

Month.	1 4-ton comp., belt driven, 7½ horse power motor direct system; ammonia coils. Consumption, kilowatt-hours (Compressor only).	2 10-ton comp., chain-driven, 15 horse-power motor direct system; ammonia coils. Consumption, kilowatt-hours (Compressor only).	3 20-ton comp., belt-driven, 35 horse-power motor; indirect system; ammonia coils. Consumption, kilowatt-hours (Compressor only)	4 15-ton comp., belt-driven, 25 horse-power motor; indirect system; ammonia coils; thermo. control; 5 horse-power motor drives fan for circulating air. Consumption kilowatt-hours.	
				Compressor.	Fan.
January	....	.....	.....	.....	....
February	....	.....	.....	.....	....
March	....	.....	1,872	.....	....
April	5	.....	3,056	.....	....
May	193	.....	3,344	.....	....
June	374	2,688	3,384	3,195	649
July	507	2,876	3,224	3,550	535
August	396	2,708	3,264	3,390	513
September	387	2,945	2,656	3,165	424
October	68	2,693	936	2,594	363
November	1	2,550	.....	1,490	204
December	....	2,087	.....	586	81
Total	1,931	18,547 (7 months)	21,736	17,970 (7 months)	2,769
Kilowatt-hours per year per square foot surface (compressor only)	0.85	2.3 (7 months)	1.45	1.84 (7 months)	

The Body Shape of Fishes*

Water Pressure as the Determining Cause

By Prof. Dr. Fr. Houssay of Paris

The theory of evolution is to-day accepted by all biologists. Their camp, however, is divided in this respect, that one group regards variability as a property inherent in the organism itself and independent of the influence of the environment; while the other group

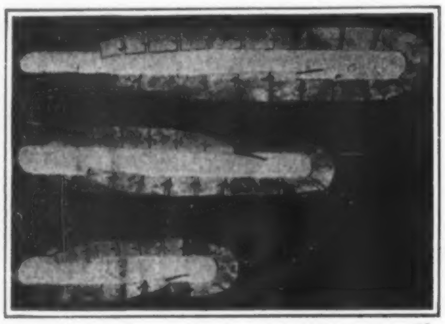


Fig. 1.—Model of the "Double Wedge" Shape With One Vertical and One Horizontal Flexible Fin.

asserts that no transformation of a living type is possible without external cause, such as the influence of food, temperature, gravitation, pressure, etc.

The author set himself the problem of demonstrating that all the morphological peculiarities of the body of fishes are the result of the pressure exerted by water on a plastic body moving through it with a certain velocity. But apart from its biological interest, this matter has also an obvious application in the field of aeronautics and submarine navigation, in which we are interested in the shape to be given to a body propelled through a fluid.

The typical fish body consists, firstly, of the trunk or body proper, and, secondly, of fins or appendages, the number of which is practically constant, though their position and arrangement is rather variable.

The essential characteristics of the typical fish body are as follows:

1. It is always larger in front than behind;
2. It displays the phenomenon of "inversion," that is to say, it is flattened horizontally in front and vertically at the back.

We will first consider the case of the typical fish, such as the shark or pike; we shall subsequently speak of some other cases, which, in addition to the typical shape spoken of just now, present a lateral flattening, such as seen in the carp, for example.

The trunk of a typical fish may be thought of as produced in the following manner:

Imagine a cone with rounded base, the broader front end of which has been drawn out into an edge by two planes whose line of intersection is horizontal and at right angles to the axis of the fish, while the rounded hind end is similarly flattened by two planes meeting in a vertical line, also at right angles to the axis of the fish. The anterior compression thus produced takes up one-quarter of the entire length of the fish, the posterior flattening the remainder.

Two questions now occur: 1, Are all fish built on this plan? and 2, Is it possible that the water has produced this shape?

To answer these questions we must consider the contour curve presented by a longitudinally extended body as viewed from the end. The cone of which we have just been speaking, when viewed from either end, presents the aspect of a circle for its contour. After it has been flattened out in the manner indicated the contour still appears simply circular or oval. If, however, the position of this contour line is clearly indicated by fastening pins all along it, and the lines then viewed from the side, it is found that it is not by any means a simple oval, but has the form of a V, the point of which is direct toward the head, and the open portion toward the tail. This curve has been determined by exact measurements in more than fifty fish of all kinds, and had been found in all cases to present a similar aspect.

Is it possible that the water has produced this shape? In order to answer this question the author has taken a long, elastic rubber bag, filled about one half to three quarters full with a plastic mixture of oil, vaseline, white lead, etc. This bag was then weighted and drawn through the water by means of a suitable device. It was found that when a certain velocity was reached the rubber bag underwent just that kind of inversion of which we have spoken above in connection with the fish body, the flattening being horizontal in front and vertical at the back. If the velocity is increased, a number of successive inversions, up to 5, 7, 9 and more, are produced.

Apart from the physical interest of these experiments, it will be seen that a single inversion is observable in the body of the fish, while multiple inversions account for the position of the alternately horizontal and vertical fins.

If the body of the fish has been molded by the action of the water, then it must be expected that it represents the form of least resistance for a given length and cross section. To prove this the author has experimented with a number of differently shaped bodies:

1. The model of a fish;
2. A cone with its point directly forward;
3. A cone with its point directly backward;
4. A double-pointed spindle;
5. A spindle with its ends flattened in opposite directions;
6. A double wedge with flattening arranged in two different planes and meeting in the center of the body.

Each model was built in three sizes, 18 centimeters, 27 centimeters and 36 centimeters, long. There were thus in all 18 models. These bodies were pulled through the water by a string with a weight upon the end. The time required for the weight to fall a given distance was noted, so that 18 comparative measurements were obtained. The mean results were as follows:

1. The fish form is not the best, but the third best;
2. It is impossible to indicate whether the small or medium size or the large offer the least resistance.

The author next hit on the idea that the law according to which the fish body was constructed relates not only to the body itself, but also to the arrangement of the fins.

The models as used all went through the water with a sinuous motion, such as one would naturally expect under the circumstances. The author suspected that the presence of the fins prevented this and caused the body to move in a straight line. He therefore provided his models with artificial fins, which were made as follows: A steel pin was inserted into the model, to form the anterior edge of the fin. Around it was rolled a suitably shaped piece of aluminium sheet, and the end of it was held by means of a rubber band, anchored farther back in the body of the fish. When this model was drawn through the water, the fins thus constructed went through an undulating motion. Fins of this kind were attached to the three most interesting models, namely, the double wedge (Fig. 1), in order to make a concrete representation of the well-known theory regarding the origin of limbs from two skin folds; second, the cone with base directly forward (Fig. 2), and third, the fish forms (Figs. 3 to 5). It was found that now every one of these models moved quite steadily through the water in a straight line at almost any velocity whatever. Only at certain special velocities the rotation around the axis of the model occurred. Under these circumstances, the following results were obtained:

The best shape for a given type was always the smallest. It was followed in order by the medium and by the large size.

Of the different types for a given length, the following was the order of merit:

1. The fish form,
2. Cone, and
3. The double wedge.

The question naturally arises, why do these models display the peculiar rotary motion? It might be supposed that by suitably introducing some asymmetry into the shape of the body, this motion might be prevented, and, as a matter of fact, in the case of whales, it is observed that the head always does show a certain asymmetry. This explanation does not however apply to symmetrical fishes. The author has therefore made a special investigation on this point. He has constructed two models of compressed form, somewhat after the manner of the carp (Figs. 4 and 5). It was found that these models did not move through the water satisfactorily. It was finally discovered that in order to obtain good results it was necessary to regulate the tension of the lower fins, in accordance with the velocity. For this purpose a rubber band was attached to a regulatable screw. It was then found that in order to get the best results it was necessary to alternately stretch and relax the rubber band as the velocity of motion was increased. In analogy with this is the observed fact that the fins of fish are expanded or contracted with changes of velocity. In the case of the rounded models, the author found it possible to prevent rotation by suitably adjusting the tension of the fins, except in the case of the conical form.

These investigations have brought many most interesting points, and a full account of them will be found in a book by the author, published under the title "Forme, Puissance et Stabilité des Poissons."[1]

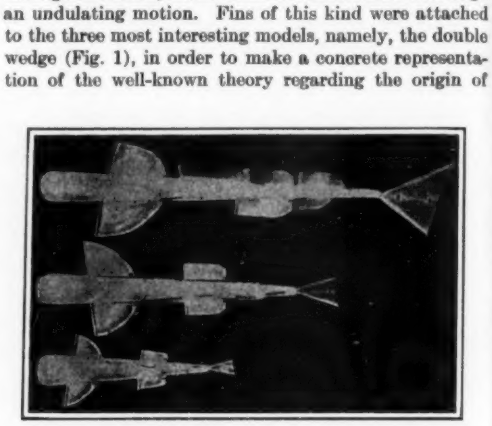


Fig. 2.—Cone-shaped Models with Flexible Fins.

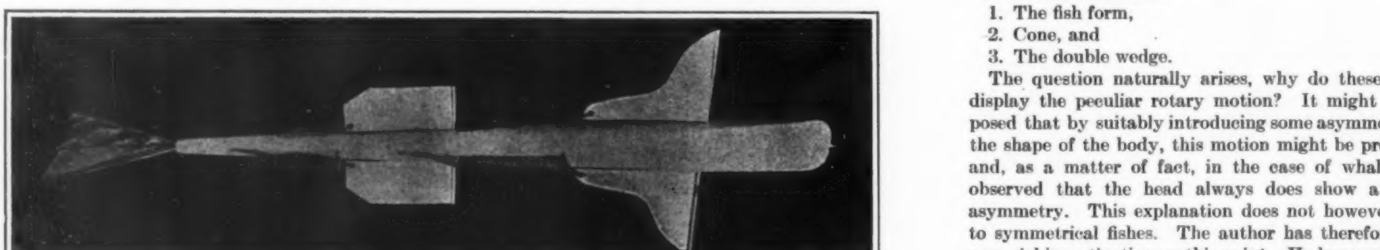


Fig. 3.—Model of a Round Fish, Such as the Shark.

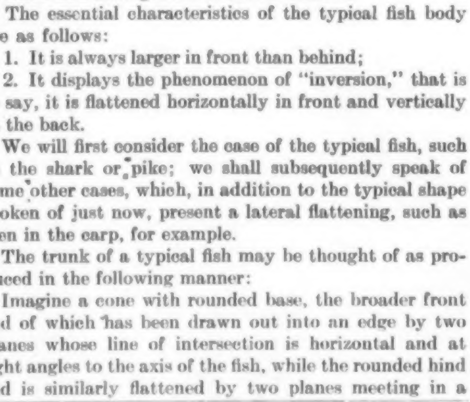


Fig. 4.—Model of the Slightly Flattened Type Without Breast Fins.

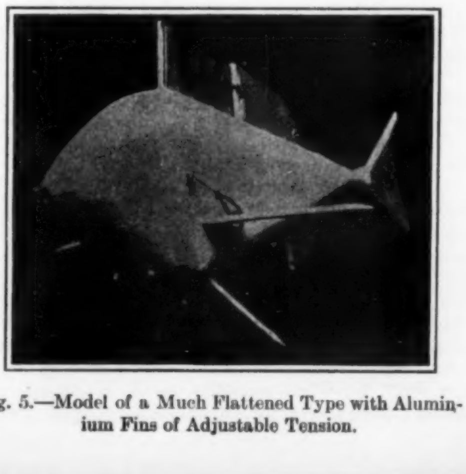


Fig. 5.—Model of a Much Flattened Type with Aluminium Fins of Adjustable Tension.

* Translated for the Scientific American Supplement from *Kosmos*.

[1] Published by Herman et fils, Paris.

The Fine Adjustment of Microscopes

Some of the Principal Modern Types

By H. Lloyd Hind, B.Sc., F. I. C.

Provision for the focussing movements of a microscope is made by means of slides, consisting of fixed and moveable parts accurately fitted together, one of them carrying the tube. The two parts are either dove-tailed one into the other, or made up of a sleeve fitted over a fixed prismatic bar, usually of triangular section. A micrometer screw is used to convey movement directly to the slide bearing the tube, or indirectly through a lever or some other mechanical arrangement for reducing the rate of motion. The prismatic bar is a most secure and accurate guide, and when it is used the action of the micrometer screw is generally direct, and raises or lowers the sleeve which carries both the arm and tube of the microscope. Dove-tailed slides are usually placed immediately behind the coarse adjustment and carry the latter and the tube only, with the advantage that the arm may be lengthened to give greater stage-room without adding to the weight borne by the fine adjustment. A direct-acting micrometer

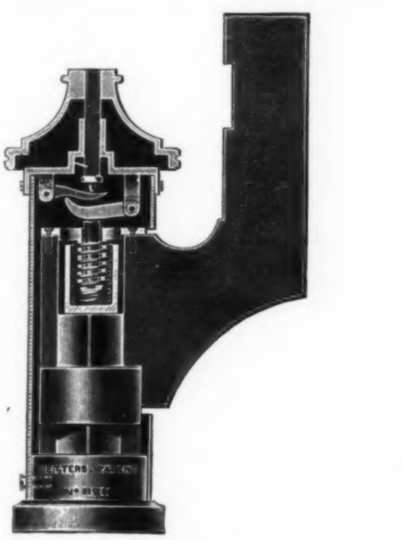


Fig. 2.—Ariston Fine Adjustment.

screw is under these conditions inconvenient, and some intermediate mechanism is usual, generally a lever, but a few makers use a cam or some adaptation of the principle of a wedge. There are many different varieties of these broad types, and the methods by which the screw or lever, and so on, are utilized, are more or less special to individual makers. The six examples given are selected as showing a fairly wide range.

The Direct-acting Micrometer Screw or Prismatic Bar Fine Adjustment.—Fig. 1 shows the form adopted by Zeiss. The arm *A* and tube of the microscope are carried on a sleeve *B* which slides upon a vertical triangular bar *C*. A nut *E* is screwed on to the top of *C* and a spring presses against it and against *B*. The hardened steel point of the micrometer screw bears on the similarly hardened center of *E* and works through *F* which is screwed to the sleeve. When the micrometer screw is turned downward the tube travels upward and the spring is compressed. The last in its turn causes the downward motion as the screw is turned up. This then is a safety fine adjustment, as the objective cannot be screwed by it down on to the cover glass. Most prismatic bar fine adjustments are liable to damage if the microscope is lifted by the moveable sleeve, but in this case the danger to the micrometer screw is minimized by fixing it to the tube carrier. If the microscope is lifted by the latter the screw is lifted too, while the lower part of the instrument drops until stopped by the counter-nut screw on top of the prismatic bar.

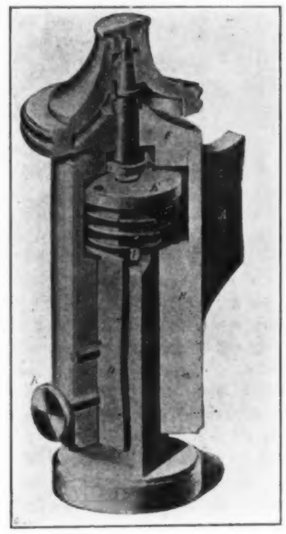


Fig. 1.—Prismatic Bar Adjustment.

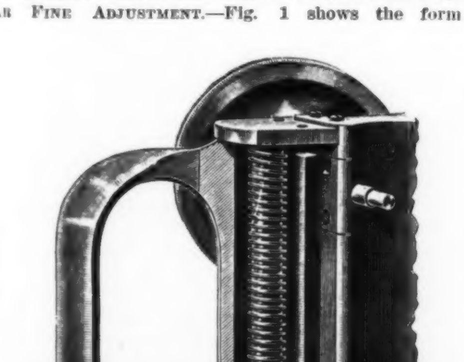


Fig. 4.—Berger Micrometer Screw Fine Adjustment.

The Ariston Fine Adjustment.—The fineness of motion imparted by a direct-acting micrometer screw obviously depends on its pitch, which is generally about one fiftieth of an inch (0.5 millimeters), and one rotation of the milled heads raises or lowers the microscope tube through that distance. This is not a very slow motion, though adequate for most purposes, and several methods have been adopted to make the movement slower. It is not advisable to use much finer screws, as they are very liable to damage. Some makers reduce the speed to one fifth by interposing two levers, while retaining the general characteristics of the prismatic bar type as shown in the Ariston fine adjustment. (See Fig. 2). This and most other prismatic bar fine adjustments differ from that of Zeiss in that the pressure of the spring raises the microscope tube, while the action of the screw presses it downward; that is, they are not generally of a safety type. On the other hand, the Ariston has the great advantage over most in that the movable sleeve carrying the limb has a protecting cover screwed over it, by which the microscope may be lifted without damage to the mechanism. The Spencer Lens Company give similar protection by fitting a small guard below the limb.

Lever Fine Adjustment.—Fig. 3 shows a simple but very efficient way of using the lever in fine adjustments, a method that, with variations in detail, is very largely employed on English and American stands. It has the following points of interest. By placing the fulcrum of the lever in suitable positions, any desired ratio can be got between the upward motion of the end of the lever carrying the tube and the downward movement of the other end caused by the screw. A very fine motion can consequently be obtained from an ordinary micrometer screw. For instance, Watson and Beck provide a movement of one three hundredths of an inch with a screw of one sixtieth of an inch pitch. In the form adopted by Baker the screw is of one seventieth of an inch pitch and the arms of the lever are as three is to one, so that one rotation of the milled head raises the tube one two hundred and tenth of an inch. It is a safety adjustment, as the downward motion is caused by the weight of the tube and the spring, which also keeps the lever always up to its work against the screw. The bearing points and surfaces are, as in all the adjustments, of hardened steel, and the limb can be used as a handle without any danger to the mechanism.

Baker's New Lever Fine Adjustment.—Fig. 6 is from a drawing of Baker's new lever fine adjustment, and is given as an example of the methods employed for utilizing a lever when the milled heads are placed at the sides. Beck's and the Spencer Lens Company use other forms of levers for the same purpose. At *A* are the milled heads; the thread of the micrometer screw *B* is fifty to the inch. Motion is conveyed by a curved lever *C*, whose ratio is one to four, to a narrow wheel *D* intended to eliminate friction as much as possible. The lever is curved where it touches *D* in such a way as to ensure that the latter carrying the tube is raised an equal amount for each rotation of the milled heads. A spring *F* on the guide

Fig. 3.—Lever Fine Adjustment.

pillar *E* keeps the wheel down to its work and causes the downward motion. Each revolution of the milled heads correspond to a movement of 0.125 millimeters or one two-hundredth of an inch. All slides in this and the last adjustment are sprung and screwed.

The position of the milled heads found in this fine adjustment is very much in favor now, and adopted by many makers, but it must not be supposed that that indicates a similarity in the working parts inclosed in the limb. That of Zeiss, for instance, is actuated by a micrometer screw (see Fig. 1).

Berger's Micrometer Screw Fine Adjustment.—(Fig. 4). The milled heads actuate a worm which in its turn rotates a cogwheel attached to the micrometer screw. The latter works in a socket firmly fixed to the sliding bar, so that if the milled head is turned to the left the tube will be raised. When turned to

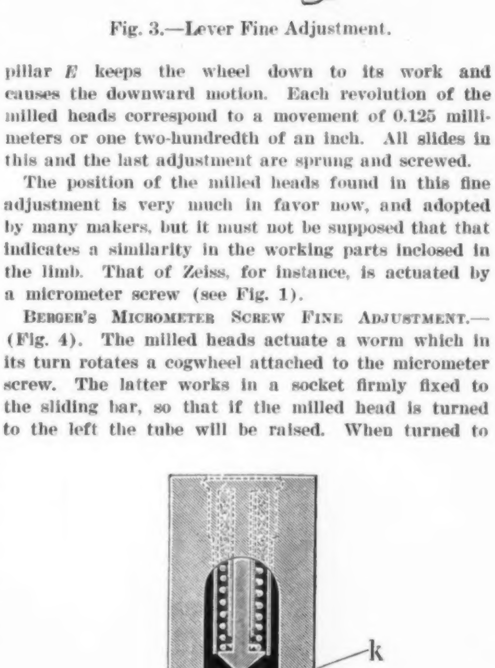


Fig. 5.—Leitz New Fine Adjustment.

the right the socket is brought downward on to the screw by the spring and tube weight only and disengages from the screw should the objective touch the cover glass. The guiding cogwheel to the left moves up or down as the milled heads are turned until it reaches the casing and so acts as a stop to the maximum and minimum movement of the adjustment. One rotation of the milled head gives a movement of one two hundred and fiftieth of an inch or 0.1 millimeter.

LEITZ' NEW FINE ADJUSTMENT.—(Fig. 5) is illustrated as an example of one of the fine adjustments in which mechanical arrangements other than a screw and lever are employed. The lateral milled heads convey motion to a wheel *d* by worm gearing. This wheel carries a heart-shaped eccentric cam *f*, and on this a steel roller is pressed by the weight of the tube assisted by a spring. As the cam is turned the roller which revolves upon it is lifted upward carrying the microscope tube with it, or falls by the weight of the last and the spring. One revolution of the milled head corresponds to a rise or fall of 0.1 millimeter (1/250-inch). Examination of the figure will show that instead of a limit to the movement of the milled heads in both directions, as there is with most fine adjustments, the motion is continuous and a further rotation when the tube is raised or lowered by the cam to its greatest extent instantly reverses the motion. The rise and fall due to the rotation of the cam is three millimeters, so that reversal need very seldom occur. Continuous fine adjustments have the advantage that there is no fear of damage due to the arrival of the movement at its upper or lower limit. But the uncertainty as to whether one is focussing up or down is occasionally a drawback, although a glance at the indicator on the sliding bar or limb serves to show the direction of movement, and as the milled heads can be made to work in the same direction as those of the coarse adjustment at any time the difficulty should seldom arise.

The milled heads of any fine adjustment can be had graduated in fifty or one hundred divisions, so that the amount of motion given can be determined when required for purposes of measurement.

The testing and selection of a fine adjustment is almost as important as the choice of objectives; for unless the former is satisfactory it is impossible to use the lenses to their best advantage. The work put into modern microscopes is so uniform in quality that the efficiency of any adjustment fitted by a maker of repute may be relied on. One may be slower in motion than another, but it is not fair to say on that account that it is better, unless the use to which the instrument will be put is known. A movement of one fiftieth or one sixtieth of an inch for each rotation of the milled heads is quite adequate for low and medium powers, and in many cases preferable to a slower one as more durable and tending to save time in laboratory work. But for high powers and particularly for photomicrography it is difficult to get too slow a fine adjustment. The advantages of a fast and slow motion are often combined in the same instrument by fixing a spindle of small diameter to the center of the milled head. It may be rapidly rotated when a faster movement is desired. Secondary levers are sometimes added to reduce the speed of a fast type, as in the Ariston, or the Males-Watson, which is provided with two milled heads. Becks use two concentric micrometer screws of different pitch to actuate their lever fine adjustment, giving movements of one sixtieth and one three hundredth of an inch respectively.

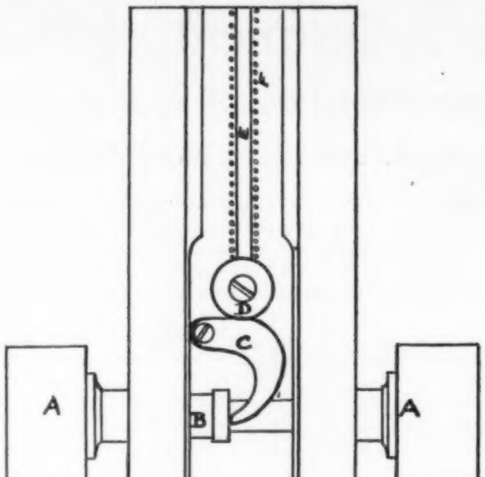


Fig. 6.—Baker's New Lever Fine Adjustment.

Safety types have a distinct advantage over other adjustments, and the liability to damage of the adjustment itself must not be overlooked.

The position of the milled heads should be such as to permit of the hand or arm resting on the table while using them.

Above all, particular attention must be paid to the sweetness and steadiness with which the adjustment works, and the following faults should on no account occur in use: Backlash, loss of time or sag on reversal of movement, lateral movement of the object across the field. And there should be no tendency for an object to go out of focus if the table receives a slight jar.

These are all guarded against by well-fitting slides and the provision of suitable springs to keep the mechanism up to its work. Good working properties are insured in different ways by different makers and it will be well in this connection to compare the advantages claimed for *sprung and ground-in slides*. If the adjustment slides of various microscopes are examined, some will be found to be "sprung" or slotted and held up true with screws, while others are not. Reliance, in the second case, is placed on the fit produced by grinding one part into the other. In support of sprung slides it is urged that when play through wear becomes noticeable, it may be taken up by tightening the screws and without returning the microscope to the maker. But against this advantage must be placed the difficulty of so exactly adjusting the screws that the slide works truly throughout its entire length and not only at a greater or less number of points. The alternative method of grinding one bearing part accurately into the other is now generally acknowledged as the better, but it involves the expenditure of much time in making a good fit and the use of very good materials if it is to wear well. Play is generally less than that in sprung slides, but when it does occur the microscope must be sent to the maker for readjustment. A good fitting should last for many years without any undue evidence of shake.

Baldness and Grayness

Their Cause and Prevention

IT has too long been the custom to relegate those arts which deal with the care of the outer aspect of humanity to the hands of the empiricist, the quack, and the charlatan as unworthy of the attention of dignified medical men. There have been signs of late years, however, of a gratifying change in this respect. Already the care of the teeth has been elevated into a vitally important branch of surgical science, and it is more and more being recognized that the skin and hair are equally worthy of hygienic care in health, of skilled treatment in disease, and of judicious measures for their maintenance in as good condition as possible throughout life.

Even a man's chance of earning a living wage and thereby retaining his own self-respect and avoiding the misfortune of becoming a burden upon society, may depend, as George Bernard Shaw has wittily pointed out, on so seemingly trivial a thing as a bottle of hair-dye! No one, in fact, who reads the "Want Columns" of a great newspaper can fail to be impressed by the fact that personal appearance is a tremendously important factor in the business world as well as the social world.

Moreover, modern physicians are beginning to lay stress on the fact that the hygienic care of skin and hair, ears, eyes, mouth, etc., may enter very seriously into the the question of the cure or the aggravation of incipient morbid conditions such as neuralgia, rhinitis, otites, and other rheumatic or nervous affections.

This is the view advanced by a French physician, Dr. Guelpa. who has just published a book on the care of the hair.[1] An article by Dr. Guelpa on this subject has just appeared in *La Revue* of Paris.

Dr. Guelpa calls attention to certain obvious aspects of the matter, such as that both baldness and grayness begin much earlier in men than in women, that baldness nearly always starts at the temples and at the crown of the head, that the hair begins to turn gray first at the temples and usually sooner than the beard, and to what he terms "the amusing observation that workmen and peasants become bald less often and less rapidly than members of the leisure classes, or than barbers and hairdressers themselves." And "why is it," he asks, "that doctors who specialize on affections of the scalp are precisely those who generally lose their hair most quickly?"

[1] "Canitié et Calvitié." Published by O. Doin, 8 Pl. de l'Odéon, Paris.

He finds the answer in the sweeping conclusion that modern hygiene of the hair is erroneous and anti-scientific.

The reasons he advances for this statement are well considered and convincing. He begins by declaring that the shampooings, frictions, and manipulations commonly employed by barbers constitute a perpetual attack on the very life of the hair, and proceeds to demonstrate this by a brief exposition of the anatomy and histo-physiology of the scalp.

We read:

"The integuments of the head are irrigated and fed by six principal groups of arteries, the occipital, frontal, and auriculo-temporal branches. All these run between the subcutaneous layer and the epicranial aponeurosis. The other vessels follow the paths of the arteries pretty closely. If we recall the anatomical direction of the latter, which spread in fan-shape from the periphery of the cranium to its summit, this arrangement will explain to us certain important facts.

"Each hair has its birth at the bottom of a canal (follicle) where the matrix (papilla) provides its nutriment. Before it emerges it traverses a sort of vesicle or 'ampulla' in which it is lubricated with sebum, a glandular oily product which lends luster and suppleness to it, and renders it impermeable and more resistant to the thermohygrometric influences of the atmosphere. To the hair is attached the flexing muscle which serves to modify the direction of the hair (as for instance in the formation of 'goose flesh'). and especially to exert a pressure on the sebaceous gland to facilitate the expulsion of its product.

"The sudorific glands contribute definitely to the equilibrium of the temperature of the scalp and may on occasion become compensating organs for the sebaceous function when this is reduced or suppressed.

"Normally the secretion of sebum as a liquid oil is constant. Mechanical irritation, anti-hygienic exterior applications, and (oftenest of all) pathologic modifications, due to acute diseases, arthritism, thyroidism, convalescence, senility, etc., produce a thickening of the sebum: it forms in its conduits, small lumps called comedons which present an obstacle to regular and complete evacuation of the gland. In the case of persons with short hair, especially when they are arthritic, the flexing muscle, under the influence of cold and humidity, ceases to act with certainty on the sebaceous glands and the comedon becomes hardened and still more firmly fixed. The gland undergoes a considerable hypertrophy and compresses the papilla, which loses its vitality. The sudorific glands, from vascular compensation, or from contiguous irritation, eliminate for some time an exaggerated secretion, slightly altered in character, which flows lavishly over the scalp, mixed with the hypersecretion of the sebaceous glands and with the detritus of the epidermis and constitutes the principal element of fatty seborrhea.

"The hair, slowly impoverished in the nutrition received from the papilla, compressed by the sebaceous tumor, deprived of the protective oily matter, excessively wet with sweaty secretions, bleaches, withers, and finally disappears.

"Subsequently the hypertrophy of the sebaceous glands continues, interferes more and more with the circirculation, and progressively diminishes the vitality of the tissues, which, compressed, strangled between the superficial layer and the epicranial aponeurosis, undergo a fatty degeneration accompanied by the definite disappearance of the hair.

"In the course of my researches I experimentally confirmed the fact, with my friend Dr. Roudino, that the scalp of a corpse well provided with hair was divided into three distinct layers, of which one, the dermis, is particularly well developed; while in a bald person this dermic zone no longer exists, the fatty hypodermic layer being substituted for it. This simple fact explains the predisposition of the obese to baldness. . . . Dr. Saboraud believed himself to have discovered the microbe of seborrhea and rashly concluded baldness must be combated by antiseptics. In this I believe he mistook effect for cause. . . . One does not accuse the vultures on a field of battle of having slain the corpses they tear to pieces. In baldness the microbacillus is attracted by the physiologic poverty of the scalp just as inferior vegetation will appear on exhausted land. If the hairs no longer sprout it is not because of their presence but because they are ill-nourished and too much compressed.

"Moreover the causes of baldness which we have just considered are not the only ones. Arthritism at every

ge plays an extremely important role in the premature loss of the hair, and it is for this reason that vegetarianism is such an effective remedy. A meat diet produces toxins which injure the functioning of the organs. One of the most important of these toxic influences is excessive acidity. This alters the nutritive properties of the blood and the lymph; the sweat becomes more acid and more irritant, the sebum tends to flow more rapidly in its conduit, and tends to form the comedon, which, increased by mistaken hygienic treatment, becomes an insurmountable obstacle to the glandular secretion and compromises the vitality of the hair.

"There is also a close connection between capillary production and circulation. When from the pressure of the hat or for divers other reasons the blood vessels lose their elasticity and diminish in caliber, that part of the scalp not irrigated deteriorates. This is why baldness always commences at the crown and around the forehead, the localities where the terminal points of the vascular system are located."

. . . .

Dr. Guelpa finds that baldness and grayness are independent of each other though commonly associated. The color of hair comes from the granules of figment deposited between the cells of the outer sheath by fluids proceeding from the deep and vacuolar portion of the follicle. These fluids should be protected by the oily coating. When this is lacking the hair loses color. Hence the worst possible treatment is that most commonly employed of applications of alkaline, acid, or antiseptic solutions, or of those containing alcohol. All of these as well as superheating tend to destroy the sebum.

Consequently the very sensible and logical conclusion to which he comes as regards treatment is that it should consist of careful, but not too frequent cleansing, followed by rubbing with some sort of oily or greasy substance to take the place of the natural oil which the necessary washing in our dusty towns and cities has removed. For this he especially recommends beef-tallow.

Correspondingly he explains that women's hair retains its good condition better than men's because it is less interfered with, since it is washed less often and not subjected to the pressure and loss of nourishment consequent on the senseless masculine hat.

"Finally," he says, "and this is an extremely important point, the *length* of the hair, protecting the scalp against atmospheric variations, is the best means of protection which nature has devised: this is systematically destroyed by the cutting of the hair too short and too frequently."

Dr. Guelpa formulates a reasonable scalp hygiene in two vitally important rules:

1. Avoid every obstacle to the circulation of the blood. Hence the hat should be light and soft or well ventilated.

2. Massage the scalp every day and do not use a comb with too sharp teeth.

The last two operations are for the removal of dead or enfeebled hairs, so that they may be replaced by young, strong hairs of greater vitality.

"Massage furthermore facilitates both the circulation and the sebaceous secretion. When suitable grease or oil is used in the process of massage (not in excess however) the comedon is softened and its expulsion facilitated."

He repeats his denunciation of the washes and "tonics" referred to above, adding that it is precisely such things that are used in histology to harden and decolorize anatomical specimens. "These lotions destroy the lubricant, chill the skin, and affect the little muscle attached to each hair." That the use of such lotions sometimes temporarily checks the fall of hair he explains very reasonably by saying that the ensuing hardening of the scalp contracts for a time the canal of the follicle around the hair ready to fall, and holds it like hardened earth surrounding a dead tree.

He warns his readers too that at least two months of regular use of the treatment recommended must elapse before definite signs of improvement may be expected, and he indulges in some ironic remarks at the expense of those who claim that baldness is an inevitable result of intellectual development and thus prognosticate the complete disappearance of the "crown of glory" from the superman!

He somewhat cruelly points his remarks by inquiring whether the present members of the bald-headed fraternity are distinguished by a lofty intellectuality, closing his article with the comforting assurance that a proper and truly scientific hygiene will insure to the most cultivated individual of the twentieth century every bit as much hair as his ancestors had.

The subject of baldness and grayness is apt to be forced upon the attention of each of us sooner or later, and while gray hair may be looked upon as conferring a certain dignity rather than as a reproach, nevertheless, premature blanching of the hair, is something of a minor affliction. Still more unquestionable is the unæsthetic appearance of a bald head, and anything which can be done to remedy these little troubles to which man is heir, represents a very definite asset.

The Manufacture of Balls for Ball Bearings*

There Are Four Distinct Stages in the Process

By L. B. Winton

The manufacture of balls as used in ball bearings, although only recently risen to a state of perfection, has been carried on for the past four thousand years.

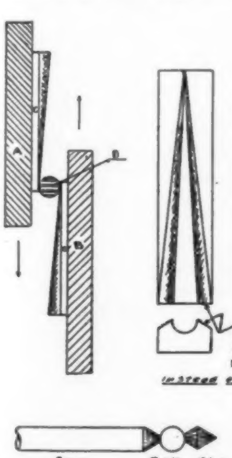


Fig. 1.

It is said that at that time the Chinese made steel balls for use in bearings.

There are four distinct stages in the manufacture of the familiar steel ball. First, the making of the blank. Second, the rough grinding. Third, the hardening, and fourth, the finish grinding.

There are three important ways of making the blanks, namely: by rolling, by turning, and by forging. One interesting device for rolling the blanks is shown in Fig. 1. Two platens, *A* and *B*, are arranged in a suitable machine so that they will run up and down in opposite directions about 100 times per minute. On the face of each platen there is a die, as shown. The bar of stock is placed in the space *D*, when the platens are in the position shown and the platens moved in the directions indicated. As the platens move over each other a ball is rolled and at the same time a small slug of waste is formed. This operation is performed cold. The chief objections to this machine are its wastefulness and its tendency to "pipe" or form a hole through the ball as shown.

A form of turning machine shown diagramatically in Fig. 2 was designed by Robert H. Grant, who designed the equipment of the Deutsche Waffen and Munitionsfabriken in Berlin, makers of the balls used by the Hess-Bright Company. The bar is held in a draw-back collet similar to that used on automatic screw machines, and is presented to the head *A*.

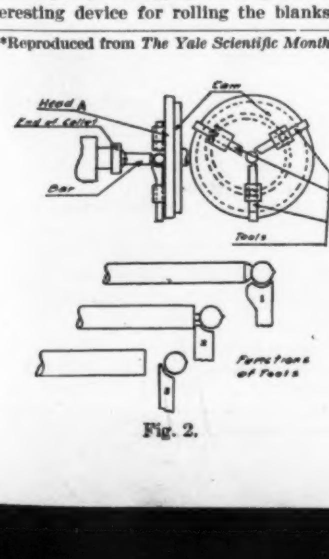


Fig. 2.

This head has tools 1, 2, and 3 whose functions are shown in the figure. These tools are brought into action by a groove cam, which is rotated, successively bringing up the tools 1, 2 and 3, thus forming and cutting off the blank. This machine was very successful and is still in use.

The forging process is one of the best for making balls from ⅜ to 2 inches in diameter and is now in wide use. A stationary die, *A*, Fig. 3, is fixed to the anvil of a drop or crank press, and a die, *B*, is attached to the hammer. The bar is inserted hot and rotated as the press hammers it rapidly, forming a "string" as shown. This string is then placed in another press and the balls are forced through the holes *C* by the punches *D*, thus separating them.

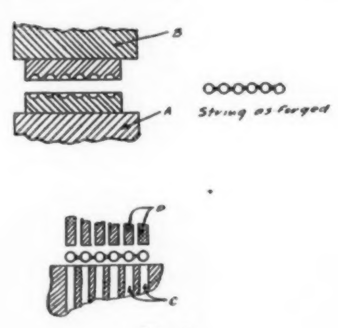


Fig. 3.

After a satisfactory blank is made, the teats left by the blanking operation are removed in the "flasher," which is a stationary disk and a revolving disk above it, between which the balls may be rolled in circular grooves. The upper disk is revolved at high speed and a considerable pressure applied. The balls are placed in the grooves with emery and oil and ground for a short time.

The balls are then ready for the first dry grinding. For doing this, there are two interesting types of machines, one type known as the Richardson type, being shown in Fig. 4, which is practically self-explanatory. The driving ring shown causes the balls to rotate on the emery wheel, thus grinding them to shape.

The balls are then ready to be hardened. First, however, they must be annealed to relieve any internal stress. They are then heated in a furnace where they are carried along by a screw of Archimedes and dropped out of the end into the hardening bath.

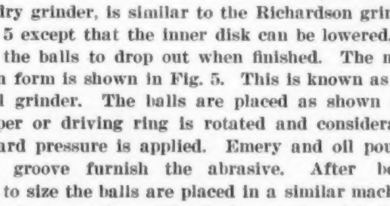


Fig. 4.

The next operation is the finish grinding. This is done in a variety of machines. One of them, the Robert Grant dry grinder, is similar to the Richardson grinder in Fig. 5 except that the inner disk can be lowered, allowing the balls to drop out when finished. The most common form is shown in Fig. 5. This is known as the ring oil grinder. The balls are placed as shown and the upper or driving ring is rotated and considerable downward pressure is applied. Emery and oil poured in the groove furnish the abrasive. After being ground to size the balls are placed in a similar machine and run for some time with oil alone, to burnish them. This gives the glass finish which all good balls have.

The alls are then inspected for size, one half a thousandth of an inch being about the maximum deviation allowed, and also for roundness. The ball itself is now finished, and it only remains to put it in some form of bearing, annular or cone, as the case may be.

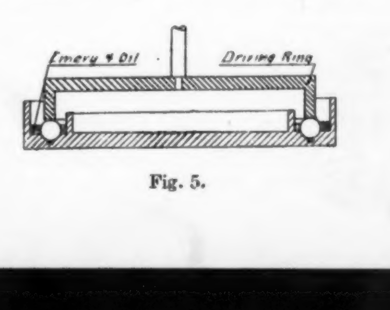


Fig. 5.

*Reproduced from *The Yale Scientific Monthly*.

Trade Notes and Formulæ

Bursting of Graphite Crucibles.—Where it is desired to effect the alloying of metals of the more costly character, it is advisable, in all such cases, to accomplish the smelting in crucibles. For this purpose those made of clay mixed with graphite are particularly well adapted, because the molten metal easily and completely separates from them. But in regards to a graphite crucible, attention should be directed to one circumstance, which, while unimportant in itself, may become very disagreeable, particularly if we are dealing with alloys of costly metals. It not infrequently happens that a graphite crucible a short time after it has been placed in the smelting furnace will burst with a loud report, the metal it contains drops into the fire and must often be recovered at the expense of much trouble. The cause of this phenomenon, as has been ascertained by repeated experience, is always due to defective workmanship in the making of the crucible. If, for instance, the crucible has in its substance, a very small bubble which may be filled with air or moisture, this body, in the course of heating the crucible must violently expand and the expansion may go so far as to shatter the crucible. As this defect in the workmanship of the crucible cannot be detected from outside, it is advisable to test every crucible before using it for fusing metal. This is accomplished by standing it where it will be gradually exposed to great heat. Very badly made crucibles usually break under this treatment, others are so thoroughly dried out that they can be employed for smelting metal without danger of bursting.

Graining Powder for Gold Articles.—Dissolve 50 parts of melted nitrate of silver in 3,000 parts of water, add to this a filtered solution of 50 parts of common salt, allow the resultant chloride of silver to settle, decant the supernatant solution of nitrate of soda, mix again by decantation, add some sulphuric acid and effect the reduction of the chloride of silver by means of pieces of zinc brought in contact with it. After these have been removed, which is more readily accomplished if the pieces of zinc used have not been too small, wash the gray looking silver powder off and dry it. One part of this powder mixed with 6 parts of common salt and 3 parts cream of tartar, and the mixture finely pulverized, constitutes the graining powder. In using, it should be mixed with water to a thin paste and this applied by means of a clean, especially greaseless, not too hard, small brush, to the article to be grained, and in order to produce an elongated graining make a few turns to right and left. The longer we brush the coarser, and the more cream of tartar we add the finer and brighter the graining will be. But too protracted a brushing must be avoided, otherwise we shall obtain not so much a graining as a bright surface, with dark spots.

To Remove Enamel.—When we desire to remove the enamel from an article, or if a piece of work has been spoiled, take a powder of equal parts of saltpeter, common salt and alum; heat the work with it to redness and cool it off in cold water. Another process consists in etching the enamel out by means of hydrofluoric acid. For this purpose, pour concentrated sulphuric acid over a suitable quantity of fluor-spar in a leaden dish (this produces fluorhydric acid) and, with the aid of a wire, immerse in it, for a short time, the article from which the enamel is to be removed. This work should be undertaken, if possible, in the open air and care must be taken neither to inhale the vapors nor to spatter any of the hydrofluoric acid on the skin, as it is one of the most poisonous and dangerous of substances and should be handled only with the greatest care. It actively attacks glass and porcelain

Casting Mass of Chloride of Zinc.—By mixing concentrated chloride of zinc solution, which must be of at least 55 deg. Be., with oxide of zinc thoroughly heated to redness, we obtain a mass that is admirably adapted for the casting of art objects; it is at least equal in hardness to marble and will take a high polish, in regard to its resistance to extraneous influences it exceeds marble in resistance quite materially, being entirely unaffected by severe cold, moisture, or even by boiling water and being also but little affected by the action of very strong acids. The casting mass is best produced by mixing 2 parts of zinc-white, which has been thoroughly heated to redness, and, after cooling, kept until needed in airtight closed bottles, with 1 part of chloride of zinc solution of 55 deg. Be. In preparing the mixture use a porcelain vessel in which the oxide of zinc is first placed, then the chloride of zinc solution added, the mixture being finally made uniform by stirring with a flat spatula. In mixing, care must be taken to prevent the formation of any air bubbles in the mixture, as their formation might result in defective castings. The well-stirred mixture is allowed to stand until it begins to become more fluid and it is then poured into the mold, where it is permitted to harden. If before use the oxide of zinc is mixed with pulverized glass or with coloring substances on which chloride of zinc excercises no chemical effect (English red, manganese, chrome green, red lead) colored casting mass can be produced.

Science Notes

The Function of the Eardrum.—It is commonly supposed that the eardrum and the ossicles of the ear serve the purpose of receiving sound vibrations and intensifying them by resonance. Dr. Zimmermann in *Die Umschau* takes a diametrically opposite view. The function of these structures is to act as dampers, which under reflex control, adjust the ear to any particular sound which it is "straining" to hear, other sounds being damped out.

A Veritable Mine of Antiquities.—The ground of the city of Mayence, Germany, seems to be inexhaustible in its supply of antiquities. On the site where the new hospital is about to be erected, there have been dug out in the course of the excavations the following articles: 130 Roman coins (among which 4 golden and 14 silver) from the time of Nero-Vespasian; 104 legion seals of the first, fourth, fourteenth and twenty-second legion; 457 legible potter's stamps; 30 primers; the inventory of a Roman smithery, a number of bronze statuettes, bronze vases and various pieces of arms.

Postal Union Statistics.—The ninety-seven States belonging to the International Postal Union have, all told, 271,000 post-offices. America heads the list with 66,663; Germany is second with 49,848 post-offices; then follows England with 23,738, Russia with 18,000, France with 13,000 and Italy and Austria each with 9,500 post-offices. These 271,000 post-offices give employment to 1,394,247 employees. Throughout the world there are mailed daily 110,000,000,000 of letters and cards. Germany's postal service is the most extensive of all. Its 49,848 post-offices employ 325,143 officials. It possesses 148,158 letter boxes. During 1909 nearly two million pieces of mail had to be sent to the Dead Letter Office. Among these were 1,300 packages, 81,700 pieces of printed matter and one half million letters.

Oxygen Additions to Iron Furnace Blast.—We read in the *Engineering and Mining Journal* that the managers of furnaces in Mülheim-Ruhr, in Ougrée, and in Kratzwieck are using small oxygen additions in the blast whenever the furnace is working cold. The oxygen is added in the form of "Linde air" (50 per cent O, 50 per cent N), a liquid-air product. An installation to furnish 17,500 cubic feet of oxygen per hour occupies a space about 125 feet square, requires about 800 horse-power to operate it, and costs about $100,000. Dr. Luhrmann finds that for each per cent of oxygen added, there is a theoretical rise of 100 deg. Fahr. in blast-furnace temperature. The manufacturers interested state that 1 per cent of oxygen on a 240-ton furnace, costs about 50 cents per ton of pig. If this cost be correct, the process is worth investigating for an emergency reserve.

Ostrich Farm.—As the result of experiments which have been made at Madagascar for a recent period by the French government department, it is found that ostrich farming can be very well carried on in this island, and this is likely to become a paying industry in the future. Ostrich feathers from this region will stand a favorable comparison upon the European markets with those coming from the Cape, and are even said to be superior in quality. An ostrich farm has been in operation for some time at Marovoay, and another establishment will soon be started near Tulear. This latter farm is laid out according to the best methods for raising the young birds and keeping the adult specimens. These two farms will serve as centers of observation and instruction so as to aid in private enterprises which it is hoped to promote by these examples. The government intends to supply the young ostriches for farming by means of annual sales so that specimens can be readily procured by would-be raisers.

Artificial Rubber Factory in Holland.—A factory to produce artificial rubber has been established at Ymuiden, the port at the mouth of the North Sea Canal. It is said that the company instituting this factory has succeeded in producing a substance having the qualities of rubber and also certain special advantages over geniune rubber. The process is a secret, but the principal ingredient of the product is said to be fresh sea fish, which are brought to Ymuiden in vast quantities by the Dutch fishing fleets. According to report 15 to 16 per cent of natural rubber is added to the fish, and the result is a substance as flexible and elastic as rubber, but much cheaper—about as 1.25 to 8 in price, compared with real rubber. The low price of this product will be caused partly by the by-products which are possible, for it is said that much albumin will be made from the fish and that half of the factory is arranged for the manufacture of guano. It is stated that this artificial rubber can be vulcanized in a short time; that it is benzine-proof and can resist the effect of heat. At first sight the substance much resembles real rubber. A slightly fishy smell betrays the chief ingredient, but it is explained that this will be prevented by extracting the fat of the fish.—*Dutch press statement forwarded by Consul Frank W. Mahin, Amsterdam.*

The Flora of Peat Bogs.—Contrary to what might be supposed, the plants which grow upon peat bogs do not present the typical appearance of marsh vegetation, namely, considerable height and thin leaves. As M. E. Coquidé remarks, with regard to peat bogs in the north of France, that the somewhat paradoxical observation is made of plants on the damp soil displaying much the same general characters as the vegetation of dry soils and he examines into the reason for this. In fact the peat soil, which is damp but not marshy, shows certain varieties of plants such as one also finds on dry soil of chalky or sandy nature. He concludes that such soil acts as if it were dry. The peat has such a great capacity for water that rain or other atmospheric water does not saturate it, and so there is a struggle between the soil and the plants for the water. The plant has powerful means for attracting water such as evaporation, capillarity, osmose and the like, but the peat also has a great evaporating power and it also retains water by capillarity, osmose and also by its colloidal nature. When the peat is nearly saturated the plant can take more water, but after a dry spell the peat does not give up its water to the plant but even subtracts it from the latter and the plant may dry up for this reason. To thrive in such a soil, the plant must be of the proper kind or adapt itself by reducing its evaporating surface and increasing its absorbing organs. This very satisfactorily explains the character of the vegetation.

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